ITT Mackay

Operation and Maintenance Manual

MSR 4020A Antenna Coupler

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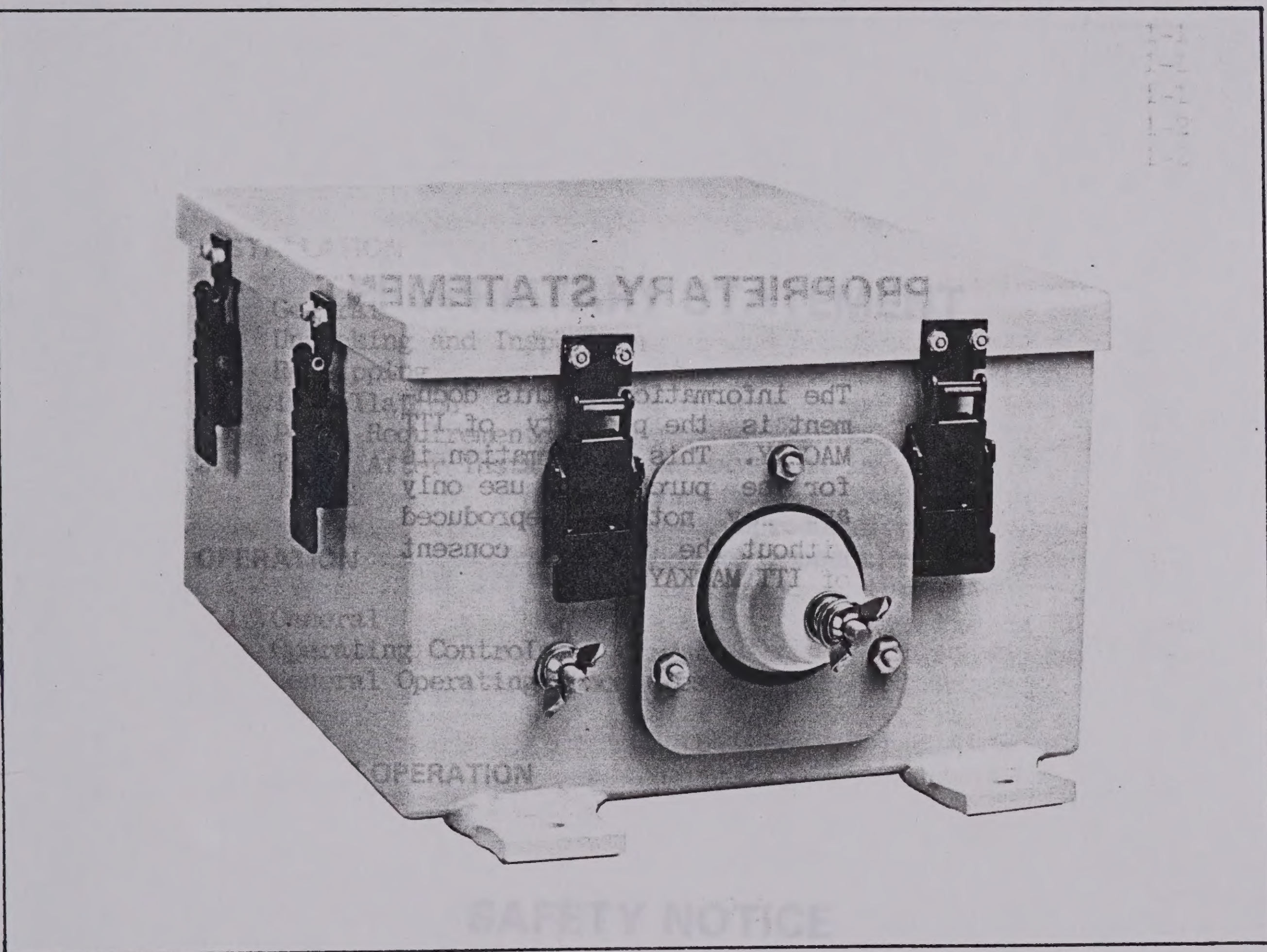

MSR-4020A
Antenna Coupler

Issue 1

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NOTICE

ITT MACKAY reserves the right to make changes to the equipment without notice.

PROPRIETARY STATEMENT

SAFETY NOTICE

This equipment has dangerous RF voltages which can cause BURNS and INJURY. Do not touch the antenna connector, long wire antenna or metal portion of whip antennas when transmitting. When practicable, maintenance should be performed with the equipment de-energized. If power-on maintenance is required, use caution. Do not touch high voltage or RF components.

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added vectorially, and because they are 180° out of phase at 50 + j0, will cause a proportional phase shift or change in magnitude and be detected by CR6 as a reflected power voltage. This voltage is peak filtered by C10 and appears as a positive DC voltage on pins 15 and 16.

4.6 CONTROL BOARD ASSEMBLY

4.6.1 GENERAL

The control board (Figures 4.5, 4.6 and 4.7) (1A2A1) contains all of the active coupler logic circuits, servo amplifiers, and the related power supply elements. 1A2Q1, the series regulator for the power supply, is mounted external to the PC board to provide for heat dissipation requirements.

4.6.2 POWER SUPPLY

The DC input power originates from the companion transmitter/transceiver and is supplied to the coupler through the same multiconductor cable used for the control functions. From the connector board, DC power enters the control board through a 26 connector ribbon cable on connector P2, pins 23 through 26.

Because the coupler may be required to operate over a wide range of DC input voltages, the unit has been designed for the two voltage groups shown in Table 4.1.

Group	Voltage Range	Connections
001	11.9 to 14.5 VDC	E1 to E2
002	22.0 to 42.0 VDC	E2 to E3

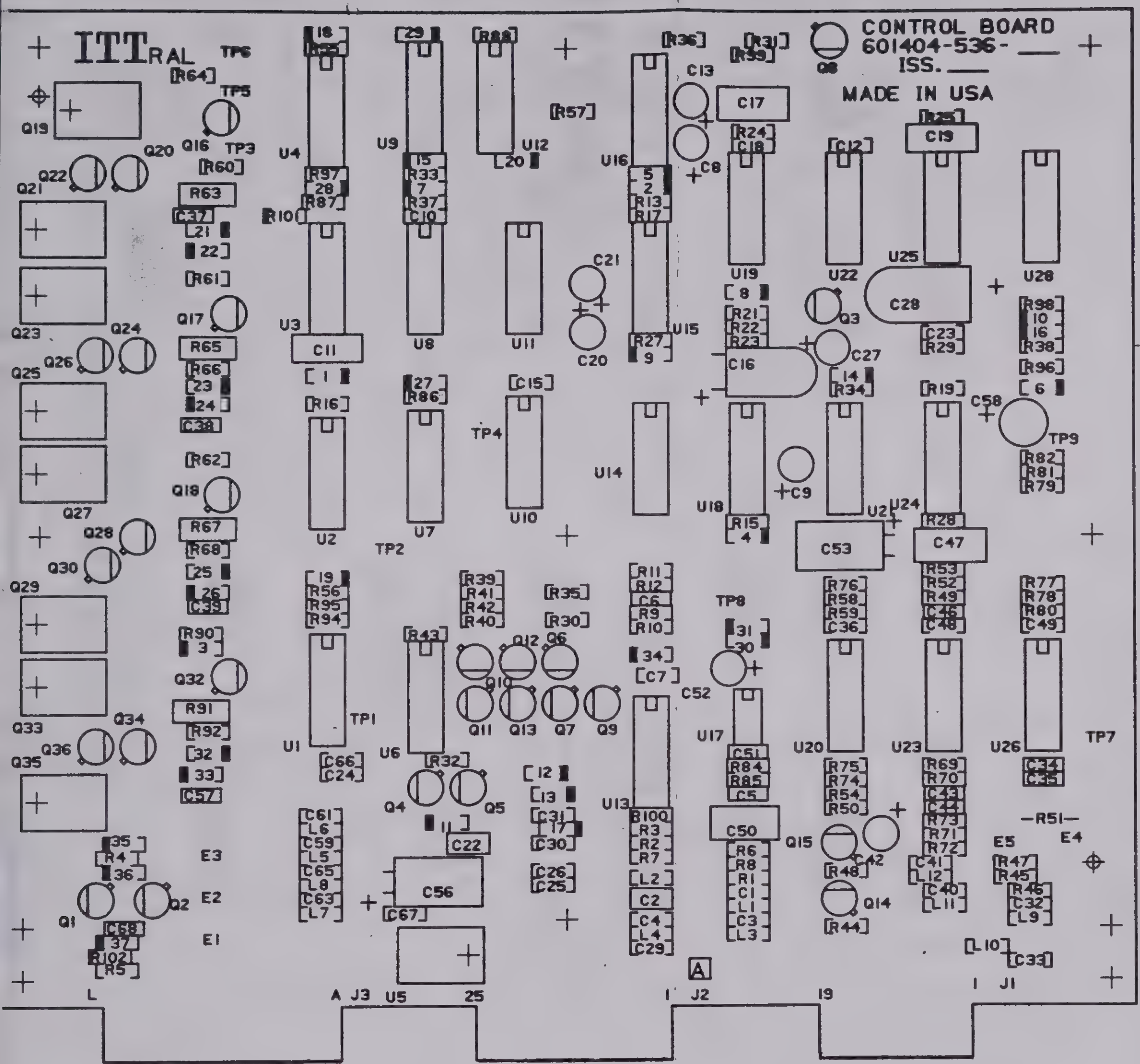
TABLE 4.1
VOLTAGE GROUPS

Configuration of a particular group requires the installation of the appropriate motors and proper strapping connections on the control board.

When operating with the Group 001 configuration, the primary power is applied directly to the servo drive system, attenuator relay, and the input to the +8V logic supply regulator, U5. The servo operating voltage is designated V_{cc}.

When operating with the Group 002 configuration, because of its wider range of input voltage, an on board 20 volt regulator is used for the V_{cc} supply. CR35 and CR36, R4 and R5, and Q1 comprise a constant current source for zener diode CR37. CR37 establishes a 20V reference voltage through Q2 to the base of the chassis mounted series regulator transistor, 1A2Q1. The regulated output from the collector of 1A2Q1 is applied, as was the primary power in Group 001, to the servo drive system, attenuator relay, and the input of U5.

The negative 5 VDC supply is obtained from a DC-DC converter and is used for powering the servo preamplifiers, comparators, and servo oscillator. IC timer U17 serves as a free running relaxation oscillator whose frequency is determined by R84, R85, and C50. The output of U17, a square wave having an amplitude of approximately 6 volts and a frequency of 125 kHz, is connected to a network consisting of C52, C53, CR30 and CR31. Series capacitor C52 causes the pulsed output to lose its ground reference before being rectified by CR30 and CR31, and filtered by C53 (the -5 VDC supply is enabled only when RF power is present. This is to insure that no noise is radiated during receive conditions).



SYMBOL	
C1,C3,C4,C7,C10 C12,C15,C18,C23-26,C29-C33,C36-C40,C41,C48,C49, C59,C61,C63,C65-67	Ca
C8	C:
C9	C:
C13,C20,C21,C42-52	C:
C2,C22	C:
C5,C6,C34,C35,C43, C44,C46,C51,C37-C39,C57,C68	C:
C27	C:
C11,C19	C:
C16	C:
C17	C:
C28	C:
C47	C:
C50	C:
C53,C56	C:
C58	C:
CR1,CR2,CR4-CR10, CR14-CR17,CR18-20,CR27-CR31,CR34-CR36,CR12	D:
CR11,CR13,CR21-CR26,CR32,CR33, CR3	D.
CR37	D
L1-12	C
Q1,Q8,Q22,Q26, Q30,Q36	T.
Q2,Q7,Q9-Q18,Q20, Q24,Q28,Q32,Q34	T
Q19,Q23,Q27,Q33	T
Q21,Q25,Q29,Q35	T
R1,R5,R6,R11,R43, R45, R47,R49,R58, R59,R70,R72,R76, R79,R81,R85,R98	R
R9,	R

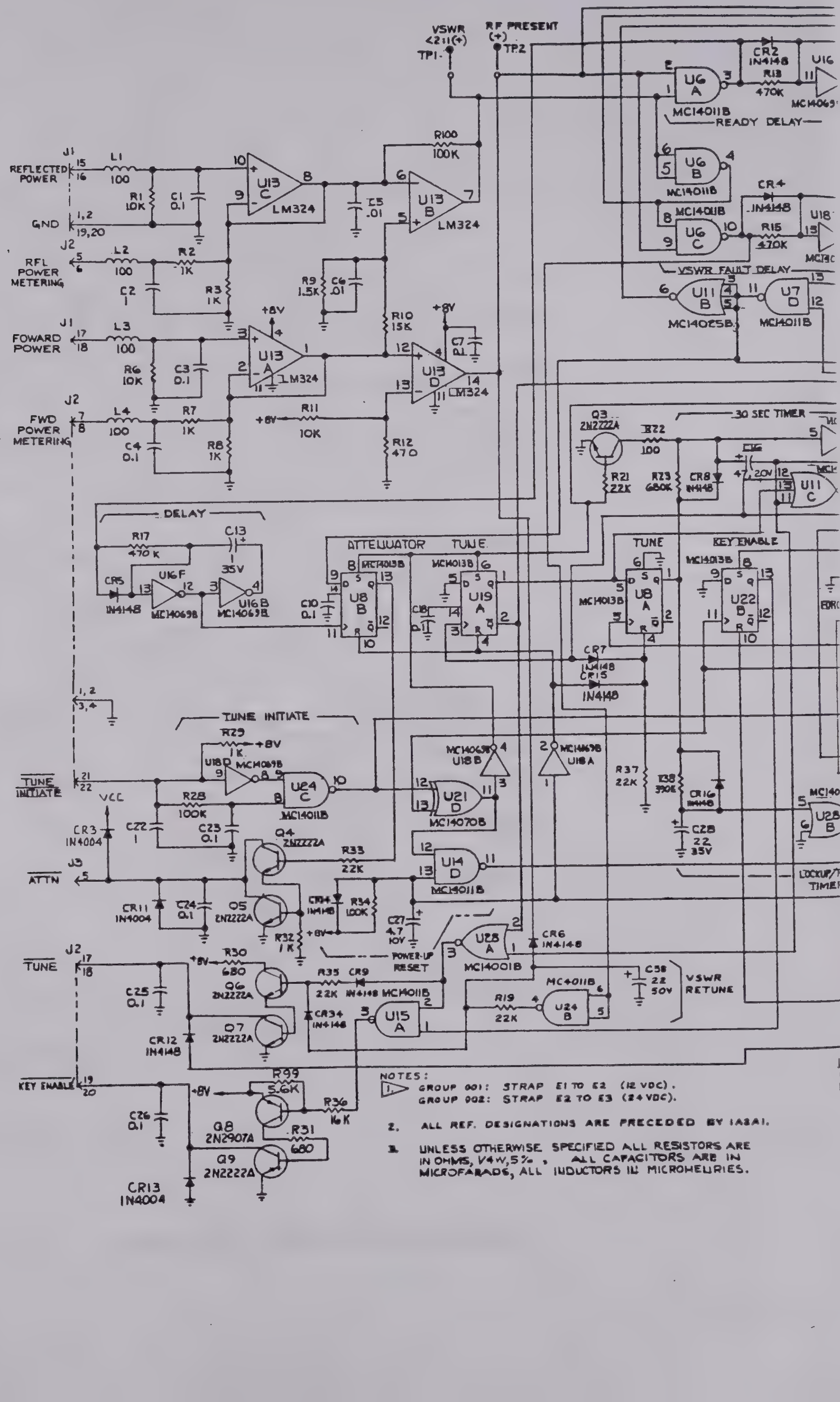
Figure 4.5 Control Board Component Location

CONTROL BOARD

DESCRIPTION	PART NUMBER
tor, .1 uf, 50V	600272-314-001
tor, 6.8 uf, 35V	600202-314-017
tor, 3.3 uf, 15V	600202-314-012
tor, 1 uf, 35V	600202-314-007
tor, 1 uf, 50V	600226-314-014
tor, .01 uf, 50V	600272-314-002
tor, 4.7 uf, 10V	600202-314-014
tor, .1 uf	600204-314-020
tor, 47 uf, 20V	600202-314-044
tor, .22 uf	600204-314-019
tor, 22 uf, 35V	600202-314-041
tor, .15 uf	600204-314-027
tor, 470 pf	647003-306-501
tor, 47 uf, 50V	600297-314-026
tor, 22 uf, 50V	600297-314-018
1N4148	600109-410-001
1N4004	600011-416-002
Zener, 1N4748A	600006-411-051
100 uH	600125-376-002
stor, 2N2907A	600154-413-001
stor, 2N2222A	600080-413-001
stor, 2N5494	600196-413-001
stor, 2N6109	600215-413-001
tor, 10K, 1/4W, 5%	610024-341-075
tor, 1.5K, 1/4W, 5%	615014-341-075

CONTROL BOARD
(continued)

SYMBOL	DESCRIPTION	PART NUMBER
R2,R3,R7,R8,R64, R66,R68,R84,R32, R92,R94-R97,R29	Resistor, 1K, 1/4W, 5%	610014-341-075
R10,R80,R21,	Resistor, 15K, 1,4W, 5%	615024-341-075
R33,R35,R37,R39, R41,R52,R53,R60-R62,R74,R75,R90, R19	Resistor, 22K, 1/4W, 5%	622024-341-075
R44,R82	Resistor, 3.3K, 1/4W, 5%	633014-341-075
R48,R78	Resistor, 2.2K, 1/4W, 5%	622014-341-075
R51	Resistor, 150K, 1/4W, 5%	615034-341-075
R55-R57, R71, R86-R88	Resistor, 3.9K, 1/4W, 5%	639014-341-075
R50,R54	Resistor, 47K, 1/4W, 5%	647024-341-075
R12	Resistor, 470K, 1/4W, 5%	647004-341-075
R13,R15,R17, R24,R25	Resistor, 470K, 1/4W, 5%	647034-341-075
R16,R28,R34, R100	Resistor, 100K, 1/4W, 5%	610034-341-075
R46,R69	Resistor, 20K, 1/4W, 5%	620024-341-075
R4	Resistor, 240 ohm, 1/4W, 5%	624004-341-075
R99	Resistor, 5.6K, 1/4W, 5%	656014-341-075
R22	Resistor, 100 ohm, 1/4W, 5%	610004-341-075
R23	Resistor, 680K, 1/4W, 5%	668034-341-075
R27	Resistor, 560K, 1/4W, 5%	656034-341-075
R30,R31,R40,R42	Resistor, 680 ohm, 1/4W, 5%	668004-341-075
R38	Resistor, 390K, 1/4W, 5%	639034-341-075
R63,R65,R67,R91	Resistor, 2.2K, 1/2W, 5%	622014-341-205
R73	Resistor, 200K, 1/4W, 5%	620034-341-075
R77	Resistor, 7.5K, 1/4W, 5%	675014-341-075
R36	Resistor, 16K, 1/4W, 5%	616024-341-075
R101,R102	Resistor, 0 ohm, 1/4W	600000-341-075
U1,U3,U28	IC, MC14001B	600078-415-101
U2,U4	IC, MC14023B	600081-415-101
U9,U21	IC, MC14070B	600188-415-101
U11,U12	IC, MC14025B	600469-415-101
U13,U20,U23,U26	IC, LM324	600171-415-001
U6,U7,U14,U15, U24	IC, MC14011B	600079-415-101
U8,U10,U19,U22, U25	IC, MC14013B	600080-415-101
U16,U18	IC, MC14069UB	600211-415-101
U17	IC, NE555	600074-415-001
U5	IC, uA78M08UC	600399-415-001

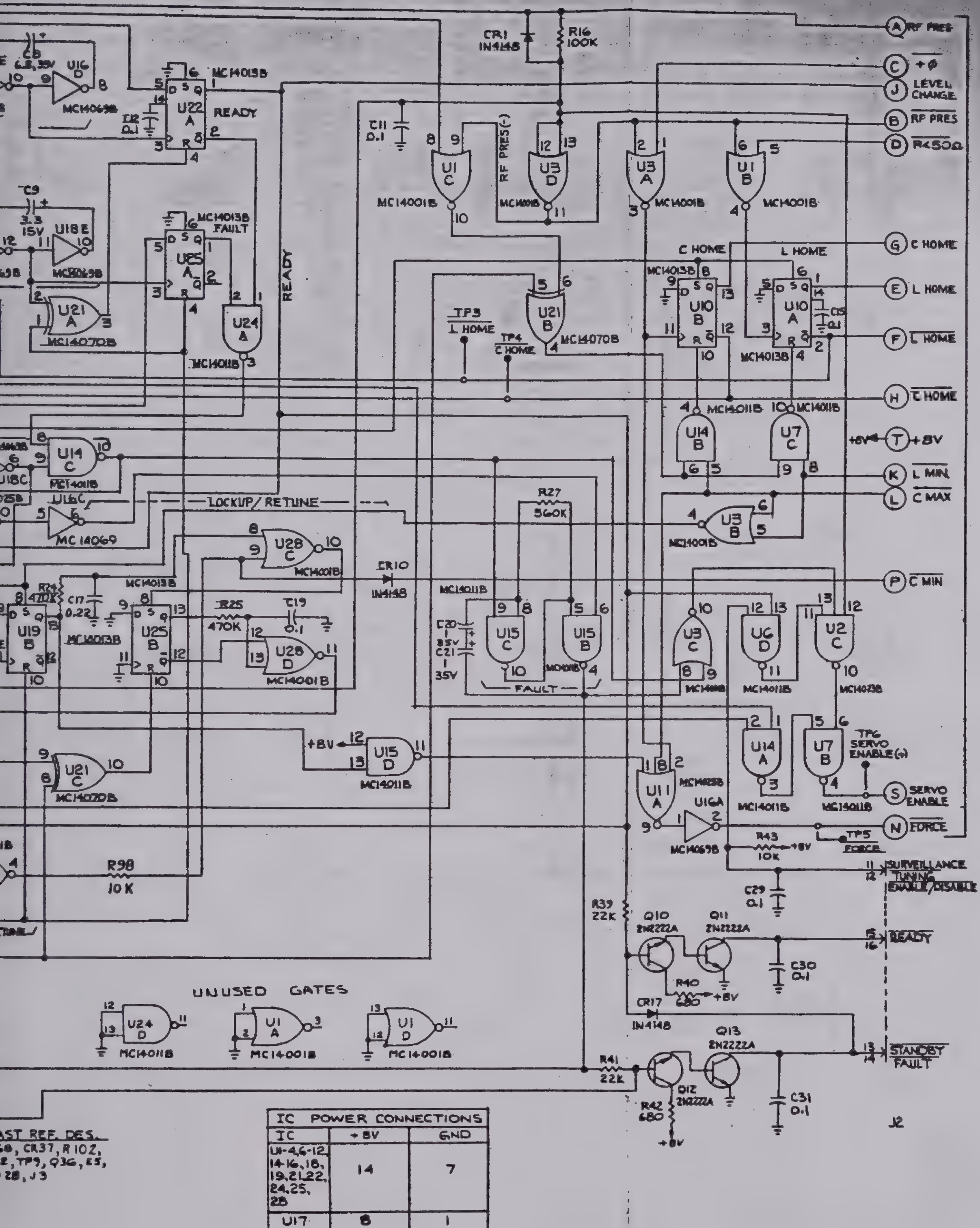


NOTES:

1. GROUP 001: STRAP E1 TO E2 (12 VDC).
   GROUP 002: STRAP E2 TO E3 (24 VDC).

2. ALL REF. DESIGNATIONS ARE PRECEDED BY 1A3A1.

3. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE IN OHMS, 1/4W, 5%, ALL CAPACITORS ARE IN MICROFARADS, ALL INDUCTORS IN MICROHENRIES.



IC POWER CONNECTIONS		
IC	+8V	GND
U1-4,6-12, 14-16,18, 19,21,22, 24,25, 28	14	7
U17	8	1

Figure 4.6 Control Board Schematic

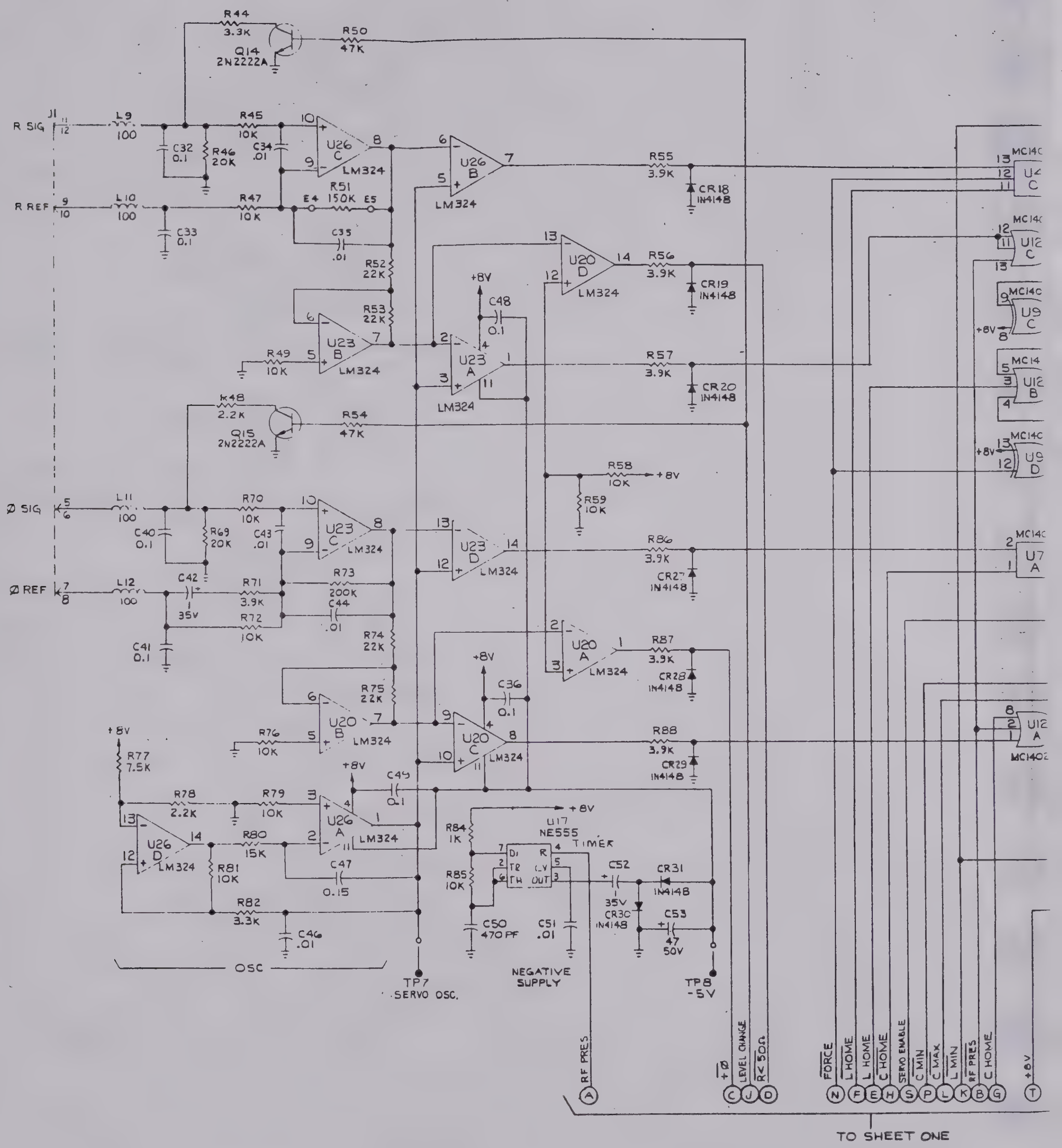
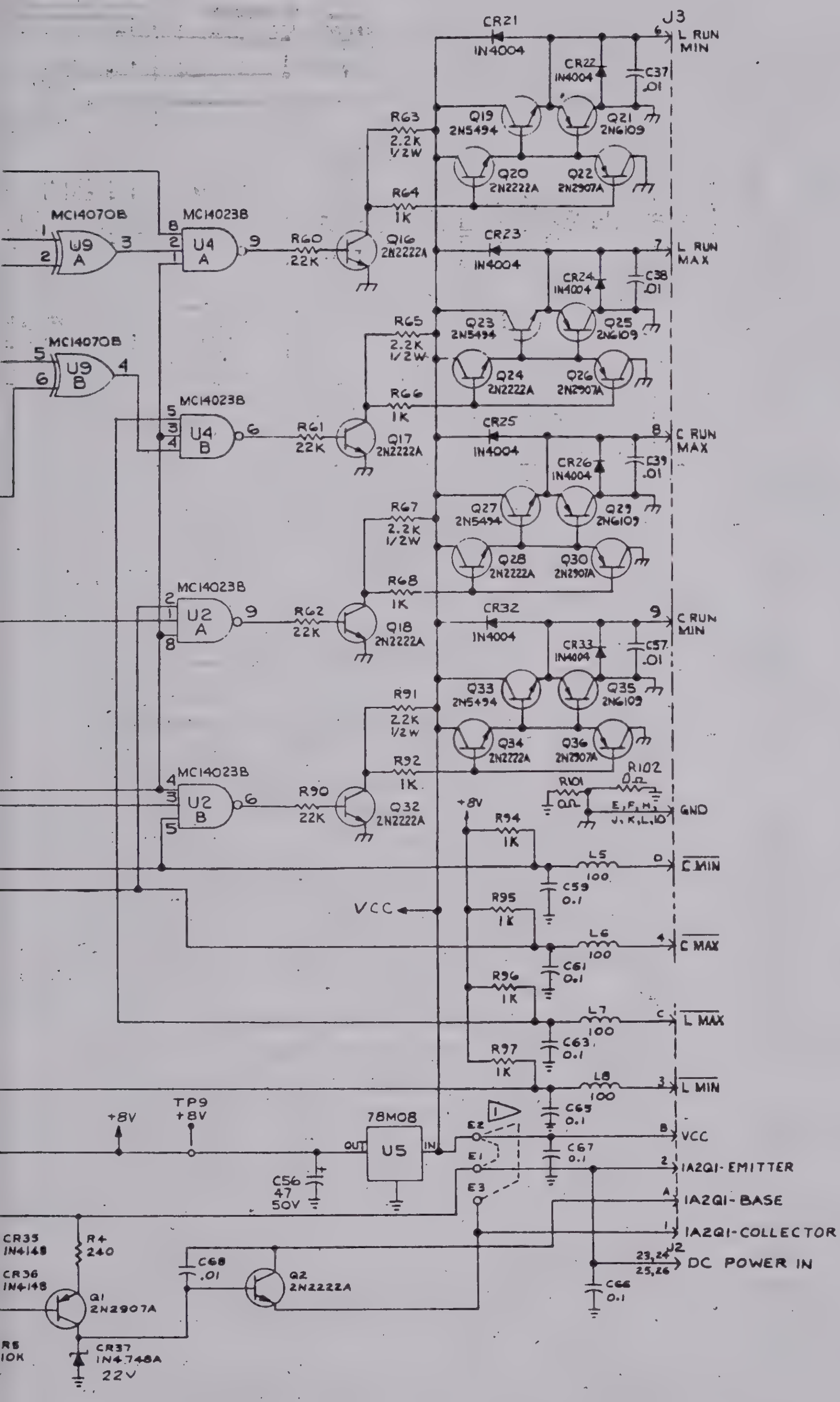


Figure 4.7 Control Board Schematic



J3
CR21 1N4004
CR22 1N4004
C37 .01
L RUN MIN
R63 2.2K 1/2W
R64 1K
Q19 2N5494
Q21 2N6109
Q20 2N2222A
Q22 2N2907A
MC14070B
MC14023B
U9 A
U4 A
R60 22K
Q16 2N2222A
CR23 1N4004
L RUN MAX
CR24 1N4004
C38 .01
R65 2.2K 1/2W
R66 1K
Q23 2N5494
Q25 2N6109
Q24 2N2222A
Q26 2N2907A
U9 B
U4 B
R61 22K
Q17 2N2222A
CR25 1N4004
C RUN MAX
CR26 1N4004
C39 .01
R67 2.2K 1/2W
R68 1K
Q27 2N5494
Q29 2N6109
Q28 2N2222A
Q30 2N2907A
U2 A
R62 22K
Q18 2N2222A
CR32 1N4004
C RUN MIN
CR33 1N4004
C57 .01
R91 2.2K 1/2W
R92 1K
Q33 2N5494
Q35 2N6109
Q34 2N2222A
Q36 2N2907A
R101 0Ω
R102 0Ω
U2 B
R90 22K
Q32 2N2222A
GND
E, F, H, J, K, L, 10
+8V
R94 1K
L5 100
C59 0.1
C MIN
VCC
R95 1K
L6 100
C61 0.1
C MAX
R96 1K
L7 100
C63 0.1
L MAX
R97 1K
L8 100
L MIN
TP9 +8V
+8V
78M08
U5
OUT
IN
C65 0.1
C67 0.1
C56 47 50V
E1
E2
E3
VCC
1A2Q1- EMITTER
1A2Q1- BASE
1A2Q1-COLLECTOR
J2
23,24 25,26
DC POWER IN
C66 0.1
CR35 1N4148
CR36 1N4148
R4 240
C68 .01
Q2 2N2222A
Q1 2N2907A
R5 10K
CR37 1N4748A 22V

All power supply voltages are referenced to chassis ground and can be checked at test points on the PC board as shown in Table 4.2.

TEST POINT	GROUP	VOLTAGE
E2	001	12.9-14.5 DC
	002	20.0 DC ±10%
TP9		+8 DC
TP8		-5 DC

TABLE 4.2
POWER SUPPLY VOLTAGES AND TEST POINTS

4.6.3 SERVO PREAMPLIFIER

Control information for the variable capacitor servo originates in the phase discriminator. This control signal enters the control board on P1 (pins 5 and 6) and is applied to the non-inverting (+) input of differential amplifier U23C. The inverting (-) input of U23C is connected to ground through a resistor located on the detector board. In this manner, both inputs of U23C will be subject to the same amount of stray hum or noise pickup. Since U23C can respond only to differences between its two inputs, this unwanted noise will not be amplified.

Inductors L11 and L12, capacitors C40 and C41 serve to remove any RF on the input lines to U23C.

The voltage gain of U23C is basically determined by the ratio of R73 and R70; therefore, the voltage gain of the preamplifier is 20. C42 and R71 comprise a damping network while C44 is used to insure that any AC on the preamp input is not amplified.

The control signal at the non-inverting input of U23C can be positive or negative as a function of the discriminator output. The output of U23C is applied through R74 to the inverting input of U20B. Since R74 and R75 are equal in value, U20B has unity gain; therefore, the voltage outputs from U23C and U20B will be equal but of opposite polarity. The outputs from U23C and U20B are also connected to the inverting inputs of comparators U23D and U20C.

R44/Q14/R50 and R48/Q15/R54 form "swamping" circuits to load down the discriminator inputs after the coupler has tuned due to the increased error voltages at high power operation. The $\overline{Q}$ output of U22A biases on Q14/Q15 through R50/R54 when a ready condition is reached. This places R44/R48 across each input to ground.

The servo oscillator, made up of U26D, U26A and associated components, produces a triangular shaped waveform having a frequency of about 300 Hz. This signal is applied to the non-inverting inputs of comparators U23D and U20C. Whenever the error signal at the inverting input of U23D or U20C exceeds the voltage at the non-inverting input, a low logic level is produced at the respective comparator's output.

A low logic level will be produced only during the period of time that the error signal exceeds the triangular signal. In this way, the analog error signal is converted into a time modulated signal whose pulse width is directly proportional to the error signal. Depending on the polarity of the error signal, this variable pulse width signal will be present on the output of either U23D or U20C. With no error signal, both outputs from U23D and

U20C will be high. R86/CR27 and R88/CR29 serve to remove the negative voltage swing from the comparator's output to prevent damage to the inputs of the following CMOS IC's. Because -5 VDC is used in these circuits, they are operational only when RF power is present.

Signal input to the servo preamp for the variable inductor originates in the magnitude discriminator. Its operation is identical to that of the variable capacitor servo preamp with the exception of the RC damping network and a lower voltage gain.

4.6.4 SERVO CONTROL LOGIC

The servo control logic is used to force the servo amplifiers to drive the tuning elements in a particular direction in response to a homing or forcing signal, to disrupt the drive when the elements are at their limits, and to remove drive entirely in response to the limits or to the servo enable/disable signal. Under tuning conditions, the control logic routes the output signals from the preamplifier/comparators to the servo amplifiers.

The control logic for the capacitor servo is comprised of IC's U12A, U2A U2B and U7A. When a homing signal is received, the output of U7A is forced high while the output of U12A is forced low. Consequently, the output of U2B will be high and, assuming the servos are enabled and the capacitor is not at its maximum limit, the output of U2A will be low. These signals, applied to the C servo amplifier, will drive the capacitor toward its home position.

The control logic for the inductor servo is comprised of IC's U12B, U4 and U9. It is important to note that a homing and forcing function cannot occur simultaneously. By following the logic paths, it can be seen that when homing, the output from U9B is low while the output from U9A is high. Consequently, the output of U4B will be high and, assuming the servos are enabled and the inductor is not at its minimum limit, the output of U4A will be low. These signals, applied to the L servo amplifier, will drive the inductor toward its home position. When a forcing signal is applied, the output states of U4A and U4B are reversed and the inductor will be driven in the opposite direction, toward maximum inductance. Under tuning conditions, as with the capacitor servo logic, the output signals from the preamplifier/comparators are routed unchanged to the L servo amplifier.

4.6.5 SERVO AMPLIFIER MOTOR DRIVER

The capacitor servo amplifier consists of two complementary power transistor pairs, Q27/Q29 and Q33/Q35, that control the motor for the vacuum variable capacitor. Q28/Q30 and Q34/Q36 combine with the power transistors to form a darlington configuration. Q18 and Q32 translate the +8 volt CMOS logic levels up to Vcc for driving Q28/Q30 and Q34/Q36, respectively.

The two complementary transistor pairs from a bridge type circuit with the motor connected across the emitter junctions of Q27/Q29 and Q33/Q35. With no positioning signal, the bases of Q18 and Q32 are supplied with high logic levels through R62 and R90 respectively. With Q18 and Q32 turned on, no drive signals are applied to the bridge circuit and no voltage will appear across the motor.

Assuming Q18 is turned off and Q32 is turned on, then the bases of Q28/Q30 will be near Vcc potential and the bases of Q33/Q35 will be near ground potential. This will bias on power transistors Q27 and Q35 and bias off Q29 and Q33. The servo motor will then turn in the direction that runs the capacitor toward its home position of maximum capacitance. When Q18 is turned on and Q32 is turned off, the situation is reversed and the motor will run in the opposite direction.

During normal operation, the bases of Q18 and Q32 will often have pulse-width modulated drive voltages applied to them. The pulse width will control the speed, since the motor will integrate the pulses across it into an average voltage. By employing this type of servo, maximum motor efficiency and proportional control are maintained, even at low error voltage levels.

Operation of the servo amplifier for the variable inductor is identical to that of the capacitor servo just described.

4.6.6 POWER ON RESET PULSE GENERATOR

Upon an initial application of power, capacitor C27 charges through resistor R34. During this time, the outputs of U14D, U21A, U18A, U21C, U14B and U7C are high and are used to reset all flip-flops. After approximately 400 ms, the voltage across C27 becomes high enough to cause these outputs to go low, thus terminating the reset pulse. Diode CR14 is used for fast recovery in the event of a momentary power disruption.

4.6.7 TUNE INITIATE

A tune cycle is initiated by a negative-going pulse on the tune initiate line J2-21. This causes a short, positive pulse to be generated that sets some flip-flops and resets others.

4.6.7.1 Set Flip Flops

Flip-flops that are set by a tune initiate pulse include U8B (attenuator), U19A (Tune), U10A (L Home) and U10B (C Home).

4.6.7.2 Reset Flip Flops

A tune initiate pulse resets U8A (Tune), U22A (Ready), U25A (Fault), U19B (Force) and U25B (Lockup/Retune).

4.6.7.3 Tune Initiate Pulse Logic

U18D, U24C, R28 and C23 comprise the Tune Pulse Logic. Initially, pin 8 of U24C is high and pin 9 is low, resulting in a logic 1 on pin 10. When a momentary ground is placed on U18D pin 9, pin 9 of U24C immediately goes high resulting in a logic on U24C pin 10. At the same time, C23 begins to discharge through R28. As soon as the voltage across C23 has fallen to a logic 0, the output of U24C returns to its normally high state. This negative going pulse from the output of U24C, lasts approximately 10 msec, as determined by the RC time constant of R28/C23. This pulse is gated so as to provide a positive pulse to set/reset the required flip-flops.

During the 10 msec that the time pulse is high, transistor Q3 is biased on and discharges the 30 second timer capacitor, C16, through R22. With U19A now set, U8A will be set as soon as its clock input receives a logic 1 from the RF Present line (TP2). When U8A is set, C16 starts recharging through R23. If the coupler tunes successfully within the 30 seconds allowed, the ready line going high will reset U19A, U8A and allow C16 to quickly discharge through CR8 to ground. Should no ready signal appear, C16 will eventually be charged enough to force the output of U18C low, signifying a time out fault.

Pin 8 of U14C will go low only if a VSWR fault occurs. Thus the output of U14C going high will indicate a fault condition for either a time out or VSWR fault. This high level on the output of U14C enables the free running oscillator, consisting of U15B, C, R27, C20 and C21, and causes the fault light to blink, indicating a fault condition.

At the same time U19A is set, both inputs of U28A are low causing its output to be high. This biases on transistor pair Q6/Q7 to illuminate the Tune light. Should a fault occur, pin 1 of U28A goes high and the tune light will extinguish.

4.6.8 LOCK UP/RETUNE

The purpose of the Lock Up/Retune circuitry is to re-initiate a tune cycle if the coupler elements have not reached their "home" positions or a ready condition has not occurred within the retune timer interval. This is necessary because the element home cycles are sometimes terminated by error signals from the detectors in order to shorten the tune cycle. However, certain antenna/frequency combinations may produce a "lock up" condition in which the element home cycles are terminated and insufficient/incorrect error signals will not allow the elements to complete tuning without going to their home positions first.

When tune flip-flop U8A is set by a tune initiate pulse, its Q output (pin 1) goes high and starts the 30 second timer and also the lock up retune timer consisting of U28B, R3 8, C28 and CR16. Approximately 7 seconds after U8A is set, C28 will charge to a logic 1 through R38 and will cause U28B pin 4 to go to a lo gic 0. This results in a logic 0 on U28C pin 9. If the force flip-flop U19B has not been set (indicating the elements have not reached home positions), U28C pin 8 will also be low. This causes U28C pin 10 to place a logic 1 on the set input of U25B. A logic 0 on U1 pin 3 will cause CR10 to force the out put of U28C high and set U25B. R25 and C19 provide a time delay so that when U25B is set, both inputs to U28D are momentarily low resulting in a short positive pulse from U28D pin 11. This pulse clocks a logic 0 through the key enable flip-flop U22B and also is gated into the tune initiate circuitry through U21D. This results in the transmitter being unkeyed and a tune cycle reinitiated resulting in the elements returning to their home positions before attempting to tune.

If a ready signal occurs before the lock up/retune timer times out, U8A is reset and causes C28 to quickly discharge through CR16 to ground.

Note that once the lock up/retune flip-flop U25B has been set, it can only be reset by a ready or power up/reset pulse. This prevents the coupler from cycling indefinately if a successful tune does not follow a lock up/retune cycle.

4.6.9 ELEMENTS HOME LOGIC

Upon receiving a positive tune pulse, the C Home (U10B) and L Home (U10A) flip-flops are set. Outputs from these flip flops are used by the servo control logic to steer the tuning elements towards their "home" positions. These cycles are sometimes interrupted in order to shorten the tune cycle time.

4.6.9.1 C Home

The C Home flip-flop may be reset by four conditions: Power UP/Reset, VSWR <2:1, positive phase (+ ϕ), or by the C element reaching its "home" position (C max). At power up/reset, a pulse is gated through U21B/U14B and applied to the reset input of U10B. During a tune cycle if the VSWR falls below 2:1, a logic 1 will be gated through U1C/U21B/U14B to reset U10B. Also, a positive phase angle signal from the Phase comparator will be gated through U3A to clock a log 0 through U10B to terminate the C Home cycle. If the C Home Cycle is not interrupted, it will be terminated when the Capacitor element engages its C Max (home) limit switch causing U14B to place a logic 1 on U10B's reset input.

4.6.9.2 L Home

The L Home flip-flop (U10A) may be reset by four conditions: Power UP/Reset, VSWR <2:1, magnitude less than 50 ohms (R<50 ohm), or by the inductor element reaching its "home" position (L Min). At Power Up/Reset, a pulse is gated through U21B/U7C and applied to the Reset input of U10A. During a tune cycle if the VSWR falls below 2:1, a logic 1 will be gated through U1C/U21B/U7C to reset U10A. Also a magnitude less than 50 ohms signal from the R Comparator will be gated through U1B to clock a logic 0 through U10A and terminate the L Home cycle. If the L Home cycle is not interrupted, it will be terminated when the Inductor element engages its L Min (home) limit switch causing U7C to place a logic 1 on U10A's reset input.

4.6.10 FORCE LOGIC

The conditions required to generate the force function will normally occur only during an initial tuning operation in the low frequency range. When the elements are at their home positions, the mismatch appears as such a high impedance load that very little line current is produced. Therefore, insufficient voltage is induced in the toroidal transformers of the discriminators and no output results. To correct this condition, the variable inductor is forced to run toward maximum inductance until the line impedance changes enough to provide an output from the phase discriminator. At this point, the capacitor and inductor will be actively driven from the discriminator outputs and normal tuning will be completed.

The actual circuit operation of the force function as follows:

At the same time that U10A and B are reset by the elements at home signal, U19B is set, making its Q output on pin 13 high. Assuming that the output of the phase discriminator is not indicative of an inductive reactance and the capacitor is at its home position, all inputs of U11A will be low. The output of U11A will be high and is inverted by U16A to result in a low level. This force instruction, which may be checked on TP5, is used in the servo control logic to force the variable inductor to run toward maximum inductance. As previously mentioned, when the capacitor moves

off its limit switch, the appropriate input of U10A goes high and the force instruction is terminated. Because there is a small time delay before the capacitor actually leaves is limit switch, an output from the capacitor drive-to-minimum control logic is also applied to the input of U11A to disrupt the forcing function. By gradually removing the forcing of the inductor as the phasing goes inductive, smoother, less violent movement is achieved. When the coupler has successfully tuned, U19B is reset by a low to high transition of the ready line applied to its clock input on pin 11.

4.6.11 RF POWER STATUS

This circuit monitors both the forward and reflected power levels, as sampled in the detector module, and provides four outputs: two metering outputs and two logic outputs. U13C and U13A buffer the forward and reflected power saamples respectively for the metering lines.

The forward and reflected power levels are compared in U13B. The values of R9 and R10 have been chosen such that VSWR levels less than 2:1 will produce a high logic level at the output of U13B called VSWR <2:1(+). This level may be checked at TP1.

The RF present (+) threshold is established by the reference voltage from divider R11 and R12 at the inverting input of comparator U13D. U13D compares the forward power output of U13A with the reference voltage to produce a high logic level at its output whenever the forward power sample exceeds this reference.

This logic level may be checked at TP2. This RF present signal is used to enable the severos when RF power is applied.

4.6.12 READY/FAULT LOGIC

To allow the coupler to achieve optimum matching, the elements are allowed to fine tune for approximately 2 seconds after the VSWR goes below 2:1.

After this delay, the ready light will light and the servos will be switched off.

The VSWR fault circuit also has a delay in order to reject minor VSWR excursions during the final phase of the tuning cycle. A VSWR fault will occur whenever the VSWR exceeds 2:1 for approximately 1 second. This short time delay allows the surveillance tuning action to operate over a wider range of mismatch than if no delay were present. During an actual tuning cycle, the VSWR is expected to exceed 2:1 and is not considered to represent a fault condition. If a matched, ready condition is not achieved within approximately 30 seconds after a tuning cycle has been initiated, a fault condition will be indicated and the servos disabled. Likewise, failure of the elements to reach their home positions will also cause a fault condition. A fault condition, for whatever reason, is indicated by a blinking of the fault light.

When DC power is initially applied, the tuned, ready/fault status of the coupler is unknown and retuning may or may not be necessry. This condition is indicated by a steady non-blinking illumination of the fault light. When RF is applied, the fault light will start blinking if the VSWR exceeds 2:1 or, if the coupler is already tuned, the ready light will light. The ready/fault detectors are always enabled and will display the coupler's tuned status as conditions dictate.

The actual circuit operation of the ready/fault logic is as follows:

U16E and U16D, CR2, R13 and C8 comprise the ready delay. When the VSWR goes below 2:1, pin 1 of U6A goes high. Pin 2 of U6A is also high whenever sufficient RF power is present. When the output of U6A goes low, C8 is allowed to discharge through R13. Eventually, as determined by RC time constant of R13 and C8 the output of U16E goes high and clocks U22A. Assuming the data input of U22A is high, as is always the case except during homing, the Q output of U22A goes high, turns on transistor pairs Q10/Q11, and places the coupler in the ready mode. CR12 is used to quickly recharge C8 when the output from U6A returns high. During a silent tune cycle the ready delay is preempted and the attenuator delay is used instead in order to shorten the tune cycle.

U18F and U18E, CR4, R15 and C9 comprise the VSWR fault delay which operates identically to the ready delay circuit only when RF power is present. U6B inverts the VSWR line so that the output of U6C goes low when the VSWR exceeds 2:1.

Assuming a ready status already exists or the coupler has just been turned on, should the VSWR exceed 2:1, the output of U18F goes high and clocks U25A. If the data input of U25A is high, as is always the case except during a tuning cycle, the Q output of U25A will go high. The data input of U25A is held low during a tuning cycle to inhibit a false VSWR fault indication.

At the same time U25A is clocked, U22A is reset. This action will remove the ready signal, if present, and make Q high. With both inputs of U24B now high, its output will go low signifying a VSWR fault.

4.6.13 ATTENUATOR CONTROL LOGIC

During the tuning cycle, a 3 dB attenuator is switched in series with the RF input to the coupler. This provides protection for the transmitter/transceiver by limiting the impedance variations while tuning. The attenuator is switched out of the circuit just prior to the completion of the tune cycle.

The actual operation of the attenuator control logic is as follows:

U8B is set by the tune pulse and turns on transistor pairs Q4/Q5. This, in turn, activates the relay in the RF Module by completing a circuit-to-ground through Q5. Should the VSWR go below 2:1 for approximately 0.5 seconds, (as determined by the time delay consisting of U16F and U16B, CR5, R17 and C13) U8B will be reset and Q5 switched off. The time delay prevents the attenuator from being removed prematurely due to minor VSWR perturbations. Likewise, the data input of U8B is held high during homing for additional protection against premature attenuator removal.

4.6.14 KEY ENABLE

The Key Enable logic causes the exciter to produce a tune power RF signal for tuning purposes. The Key Enable line J2-19, 20 goes to the exciter to control the exciter RF tune signal.

The Key Enable condition occurs after the Key Enable flip-flop U22B has been set and a tune cycle is in progress. U22B is set when both inputs to U3B are low, signifying the elements have reached home positions. When this occurs, U3B's output goes to logic 1 and sets U22B.

U22B is reset by a Power Up/Reset pulse, Lockup/Retune function, or a fault condition. Therefore the Key Enable line will normally go to a logic 0 upon tune initiate unless one of these conditions has occurred.

When a Tune Cycle is in progress U28A's output will be high and U15A pin 1 will be high if U22B has been set. U15A's output is inverted by U16C and turns on transistor pairs Q8/Q9. When U22B is reset by a Ready or U28A pin 1 goes to a logic 1 due to a cycle time out, the Key Enable line will return to a high state unkeying the exciter.

4.6.15 SERVO ENABLE LOGIC

The servo enable logic is used to turn the L and C servo systems on and off as required. The servo system is enabled during homing and tuning, and is disabled whenever power is initially applied, if a fault condition exists, or in the absence of sufficient RF power. The servo system is normally switched off after the coupler has tuned and the ready light lights. However, should the surveillance tuning feature be enabled, the servos will remain on.

The actual operation of the servo enable logic is as follows:

U3C produces a low level at its output whenever a fault condition exists or when the coupler is initially turned on. As a result, the output of U2C and pin 6 of U7B will be forced high.

During a homing condition, both inputs to U14A will be high; therefore, the output of U14 and pin 5 of U7B will be low. This forces the output of U7B high and the servo system is enabled to allow the elements to run toward their home positions. If the elements fail to home within the allotted time, pin 2 of U14A will go low and the output of U14A will go high. With both inputs of U7B now high, the output of U7B will go low and the servo system will be switched off.

At all times other than homing, pin 1 of U14A will be low, resulting in pin 5 of U7B being high. Consequently, the servo system will be controlled by the output status of U2C. A low on any input of U2C will turn the servos off.

As mentioned previously, pin 13 of U2C will be high in the absence of a fault or initial power on and pin 12 will be high whenever sufficient RF is present. The logic state of the remaining input of pin 11 is determined by the output status of U6D . If the Surveillance tuning feature is disabled, pin 12 of U6D will be pulled high through R43. When a tuning cycle is underway, the output of U6D will still be high since pin 13 of U6D will be low. However, after the coupler is tuned, pin 13 will go high with the Ready signal, the output of U6D will go low, and the servos will be switched off. Should Surveillance tuning feature be enabled, pin 12 of U6D will be pulled low and the output of U6D will be forced high.

4.6.16 VSWR RETUNE LOGIC

U24B, R19, C58 and CR6 comprise the VSWR RETUNE circuitry. Whenever the conditions occur such that RF is present (TP2 is high) and the VSWR >2:1 (TP1 is low) this circuitry causes the TUNE output J2-17,18 to go to logic 0. This signal may be used by some exciters to initiate an automatic tune cycle whenever these conditions occur.

The output of U6C will be low whenever this untuned condition exists. U24B inverts this signal and applies it to the base of Q6 through R19 and CR34. C58 and R19 provide a delay to remove any false-triggering transients, thus, Q7 turns on to place a ground on the TUNE output. CR6 discharges C58 whenever TP2 is low.

4.7 CONNECTOR BOARD ASSEMBLY

The connector board (1A1A1, Figures 4.8 and 4.9) provides DC power and control line interconnections between the external control cable and the coupler circuitry. The control line connector is mounted on the PC board and is secured to the case by 6-32 threaded studs.

The connnector board is connected to the control board by a plug on 26 conductor ribbon cable. All lines are bypassed by axial lead capacitors on the connector board (See Figure 4.10 for all chassis interconnections).

In addition, a miniature slide switch is mounted near the top edge of the connector board. This switch provides a user serviceable method of selecting the surveillance tuning feature if an external switch is not used.

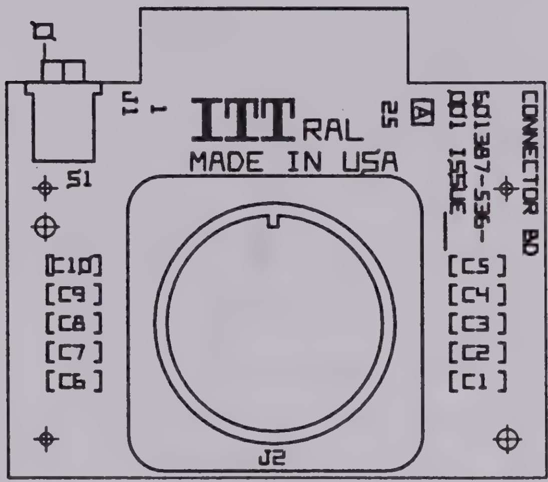
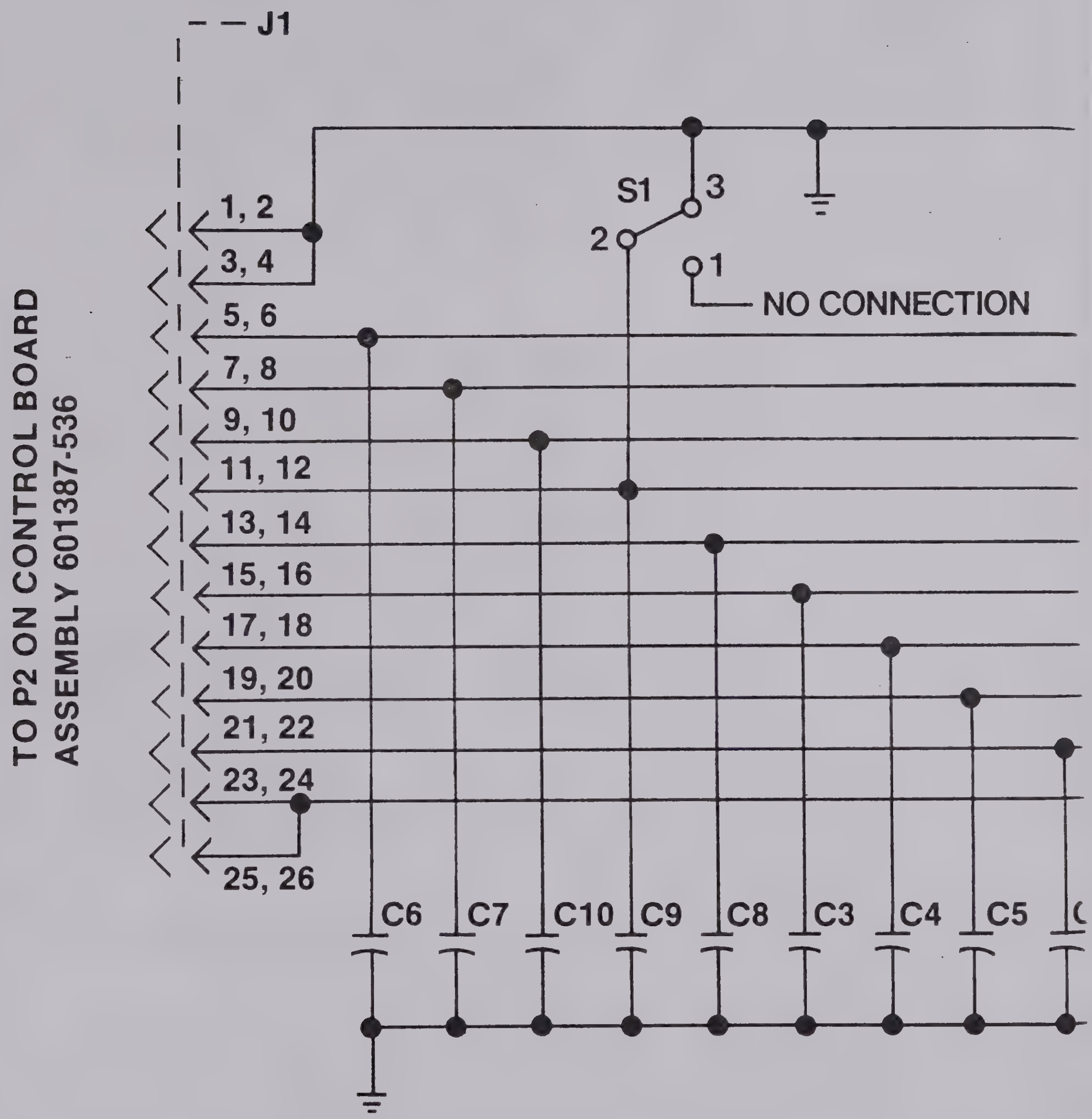


Figure 4.8 Connector Board Component Location

CONNECTOR BOARD

SYMBOL	DESCRIPTION	PART NUMBER
C1-C10	Capacitor, 0.1 uF, 50V	600272-314-002
J1	Connector	600374-606-014
S1	Switch, slide, SPDT	600276-616-001



NOTES:

1. ALL CAPACITORS ARE .1 uF.
2. ALL REF. DESIGNATIONS ARE PRE

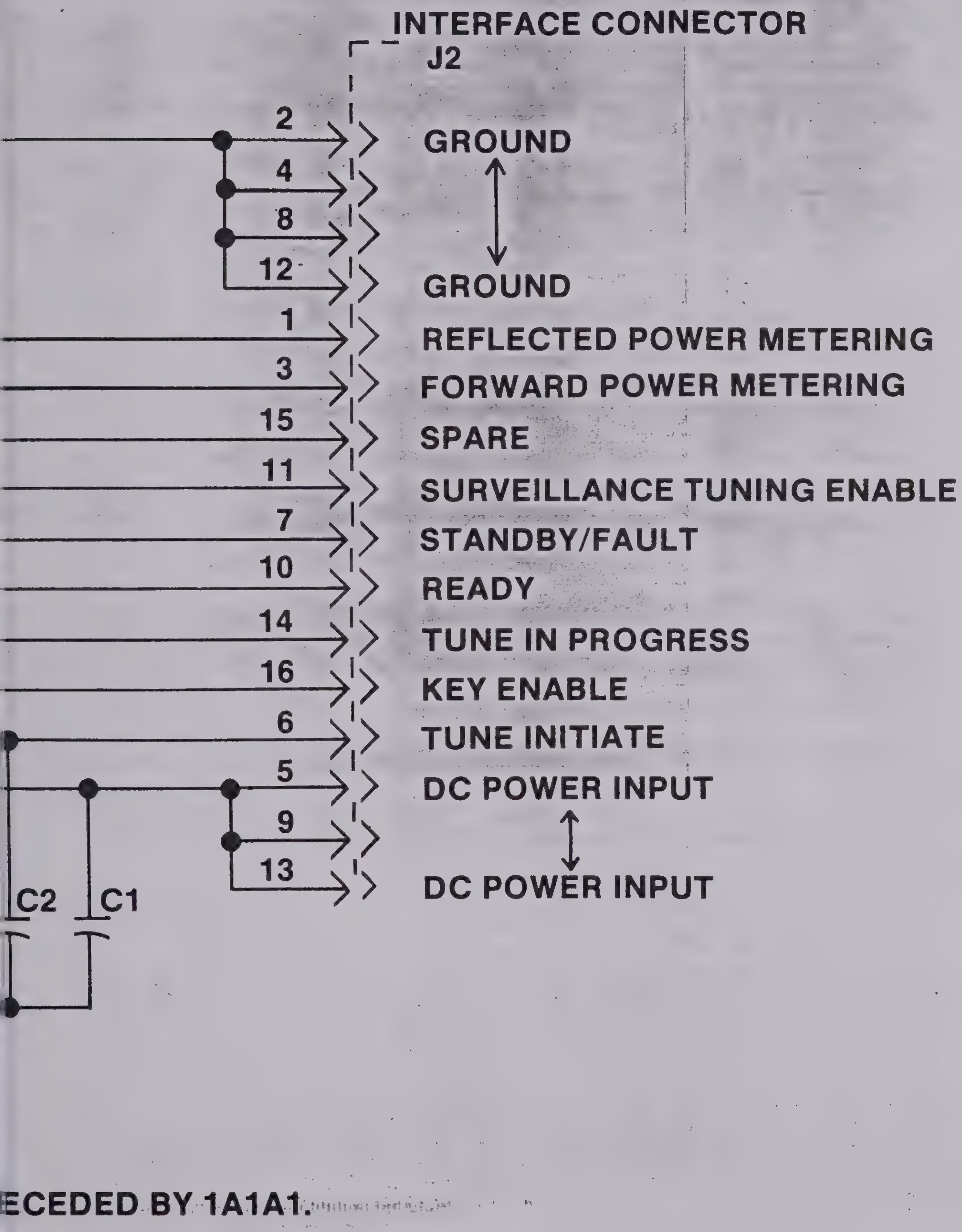


Figure 4.9 Connector Board Schematic

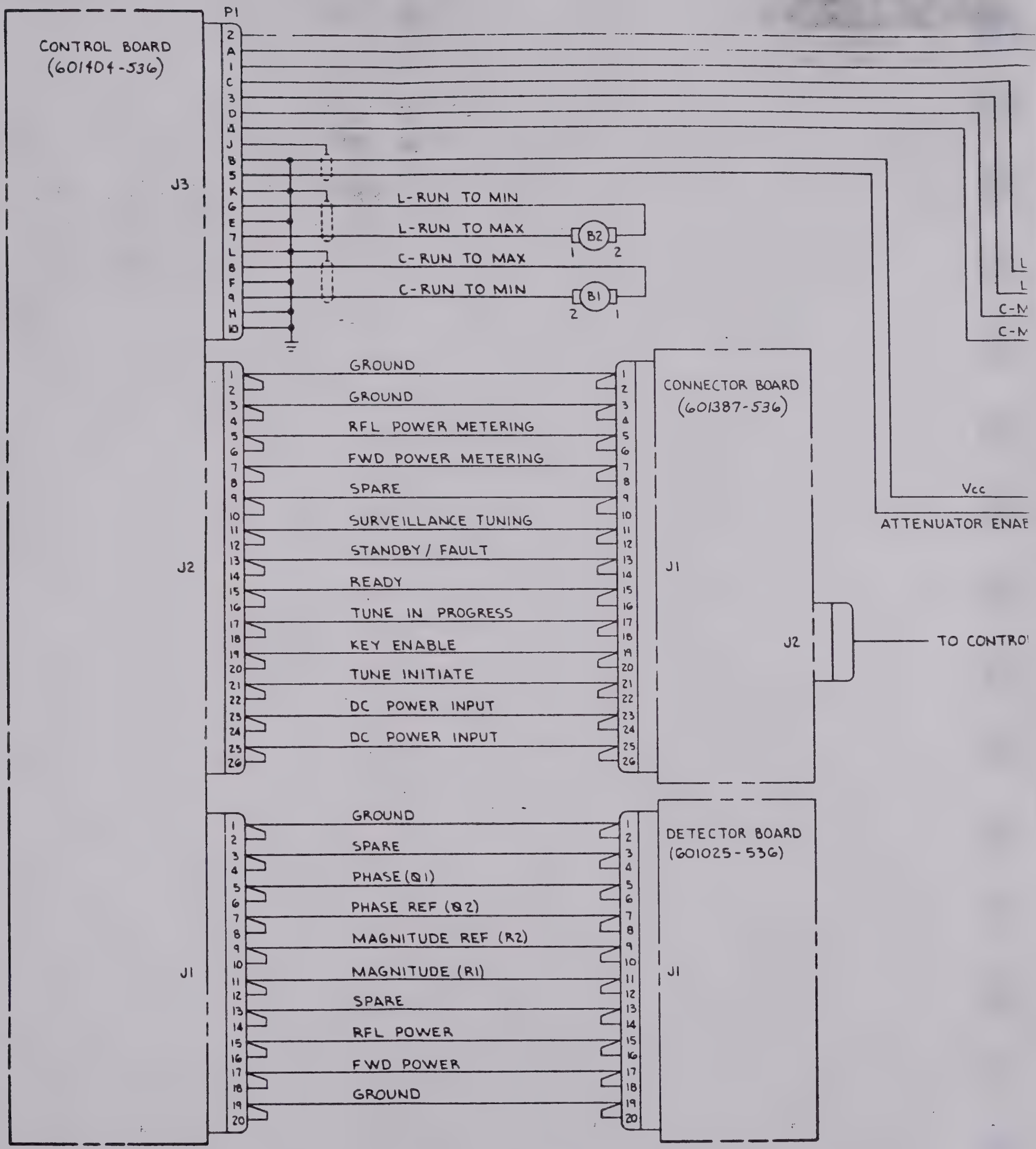
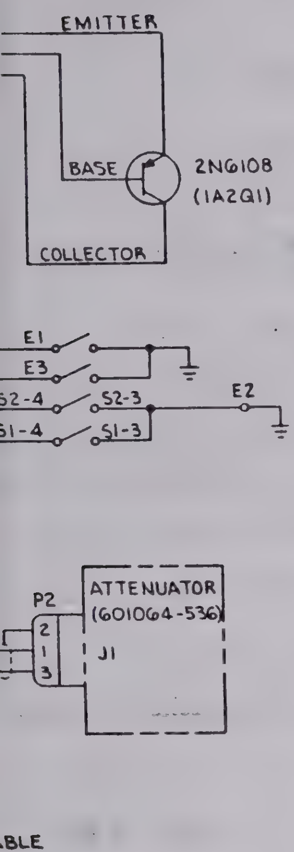


Figure 4.10 Chassis Interconnect



EMITTER
BASE
2N6108
(1A2Q1)
COLLECTOR
E1
E3
S2-4
S2-3
E2
S1-4
S1-3
P2
ATTENUATOR
(601064-536)
J1
2
1
3
BLE

4.8 ATTENUATOR ASSEMBLY

4.8.1 GENERAL

The function of the attenuator in the coupler (Figures 4.11 and 4.12) is to provide a series 3 dB pad to limit impedance and VSWR variations during the tuning cycle.

The attenuator pad is designed to operate over the frequency range of 1.6-30 MHz. It consists of RF input and output terminals, a relay to control the routing of the RF, a 3 dB resistor L pad, and a relay control terminal.

4.8.2 RELAY

A DPDT relay is used to route RF power from the input (E1) to the output (E2) of the attenuator board. When the relay is de-energized, it provides a direct, low loss path from E1 to E2. However, during the coupler tuning cycle, the relay is closed, routing the RF power through the 3 dB resistor pad before going to the tuning elements.

4.8.3 3 dB ATTENUATOR PAD

The 3 dB pad used in the attenuator board consists of six, 10 watt, non-inductive resistors. They are used in an L pad configuration that gives approximately 3 dB of loss, and limits worst case VSWR to a nominal 3:1. The 1k, 10 W resistor, R7, serves a a wide band load for the harmonious from the amplifier. The pad has a total power handling capability of 60 watts and is required to dissipate 25 watts average power during the tuning cycle (50 watts -3 dB).

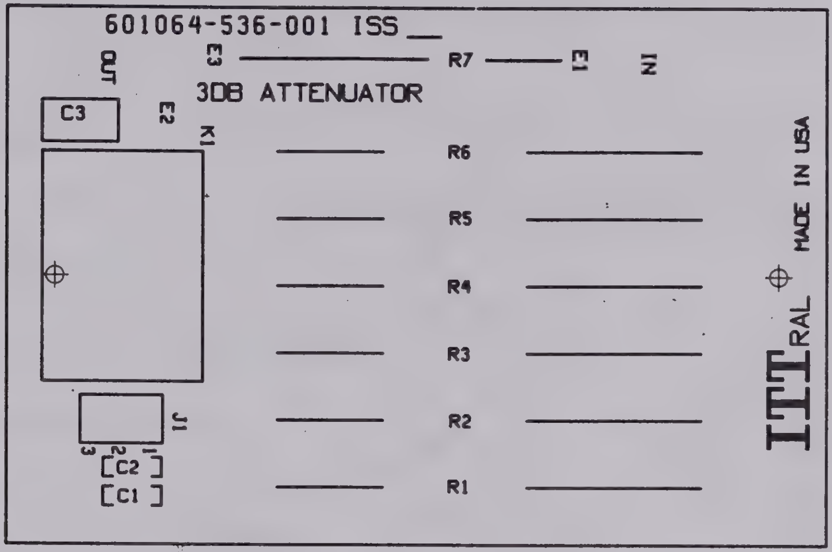
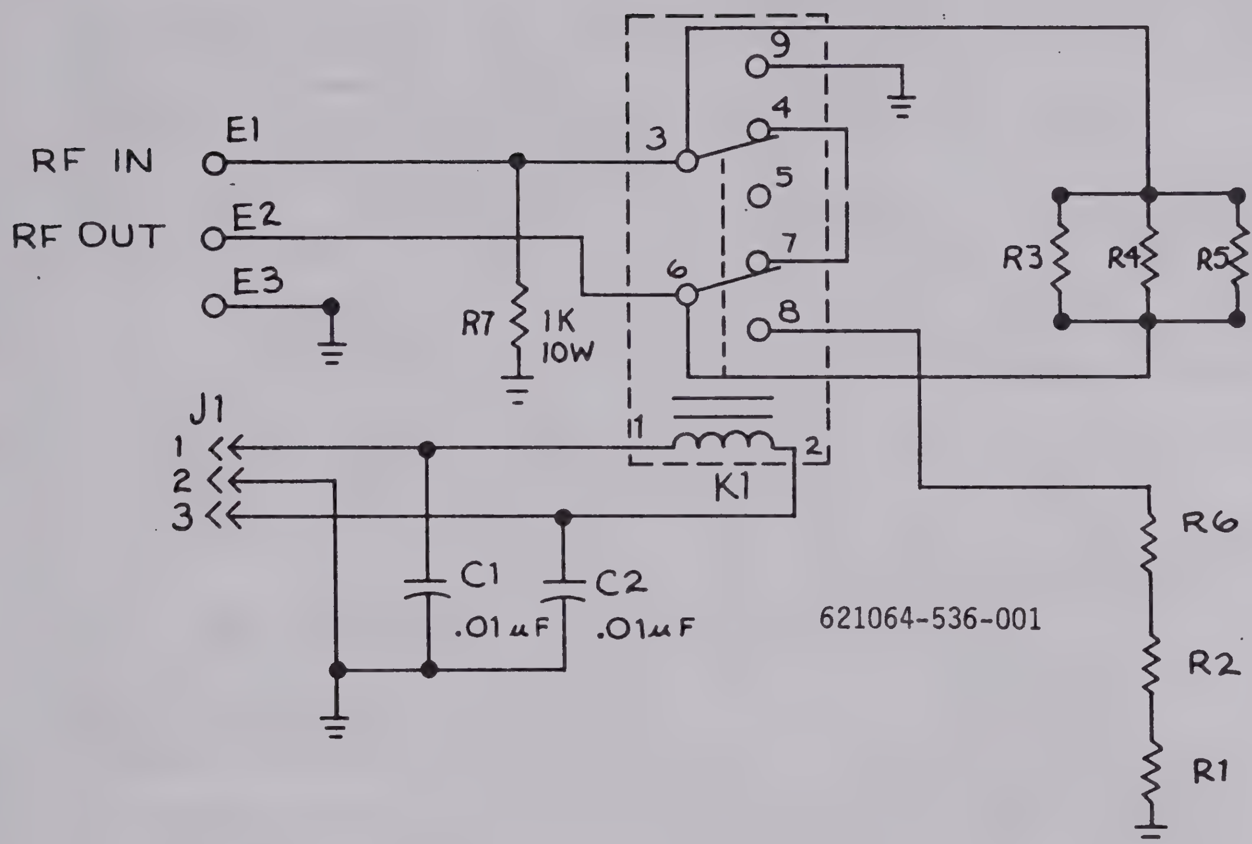


Figure 4.11 Attenuator Board Component Location

ATTENUATOR BOARD

SYMBOL	DESCRIPTION	PART NUMBER
C1, C2	Capacitor, .01 uF, 50V	600272-314-002
J1	Connector, 3 position	600078-608-025
K1	Relay, DPDT, 12V	600052-403-003
R1 thru R6	Resistor, 50 ohm, 10W	600082-340-001
R7	Resistor, 1K, 10W	600062-340-046



NOTES:

1. ALL RESISTORS ARE 50 OHM 10 WATT.

2. ALL REF. DESIGNATIONS ARE PRECEDED BY 1A2A3.

Figure 4.12 Attenuator Board Schematic

SECTION 5

MAINTENANCE AND REPAIR

5.1 GENERAL

This section provides test procedures for routine maintenance and evaluation of overall coupler performance. A fault analysis table is included to aid in the isolation and repair of a defective assembly or circuit board. Figures 5.1, 5.2 and 5.3 identify major components.

CAUTION

RF from the transmitter can cause high voltages within the coupler. Care should be taken to avoid RF burns.

5.2 TEST EQUIPMENT

The following test equipment or equivalent is required for troubleshooting and repair of the coupler:

1) Companion transceiver or equivalent source of RF power
2) Wattmeter: Bird Model 43 with 50 watt, 2-30 MHz element
3) Dummy Load: 50 ohm, 100 watt
4) HP410B VTVM or equivalent
5) Detector RF Cable Assembly (Figure 5.5)

5.3 PERIODIC MAINTENANCE

In order to assure continued trouble-free operation, the coupler should receive periodic inspection and maintenance. The desiccant should be inspected every six months following the procedure outlined in paragraph 2.6.4. In addition, the following maintenance should be performed every twelve months on the remaining components of the coupler.

5.3.1 EXTERNAL INSPECTION

Inspect the coupler for dust and other foreign particle accumulation on the antenna insulator, loose electrical connections, and evidence of arcing or corrosion. The unit should be cleaned as required using a soft cloth moistened in a mild detergent.

5.3.2 INTERNAL INSPECTION

1) The cover for the coupler is secured to the lower enclosure by 8 spring type latches.

CAUTION

Care should be exercised when releasing the latches to prevent their snapping up against hands or fingers.

Inspect the neoprene cover gasket for signs of deterioration and possible water leaks.

2) Check all hardware and retighten if necessary.

3) Apply a small amount of Aero Lubriplate grease to the threaded shaft and thrust bearing assembly of the vacuum variable capacitor. The capacitor sleeve should be lubricated with 2 or 3 drops of a light machine oil.

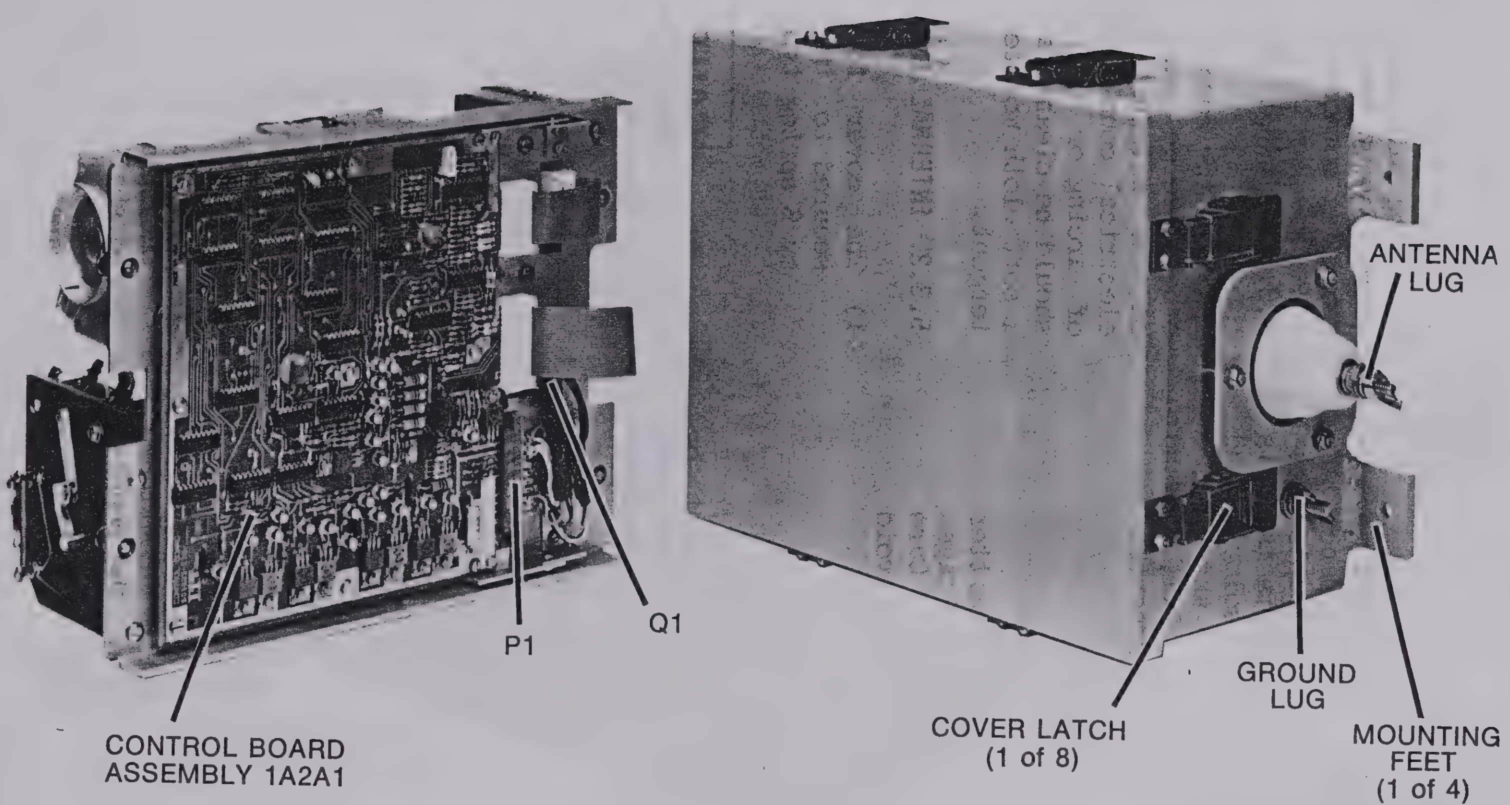


Figure 5.1 Major Component Location

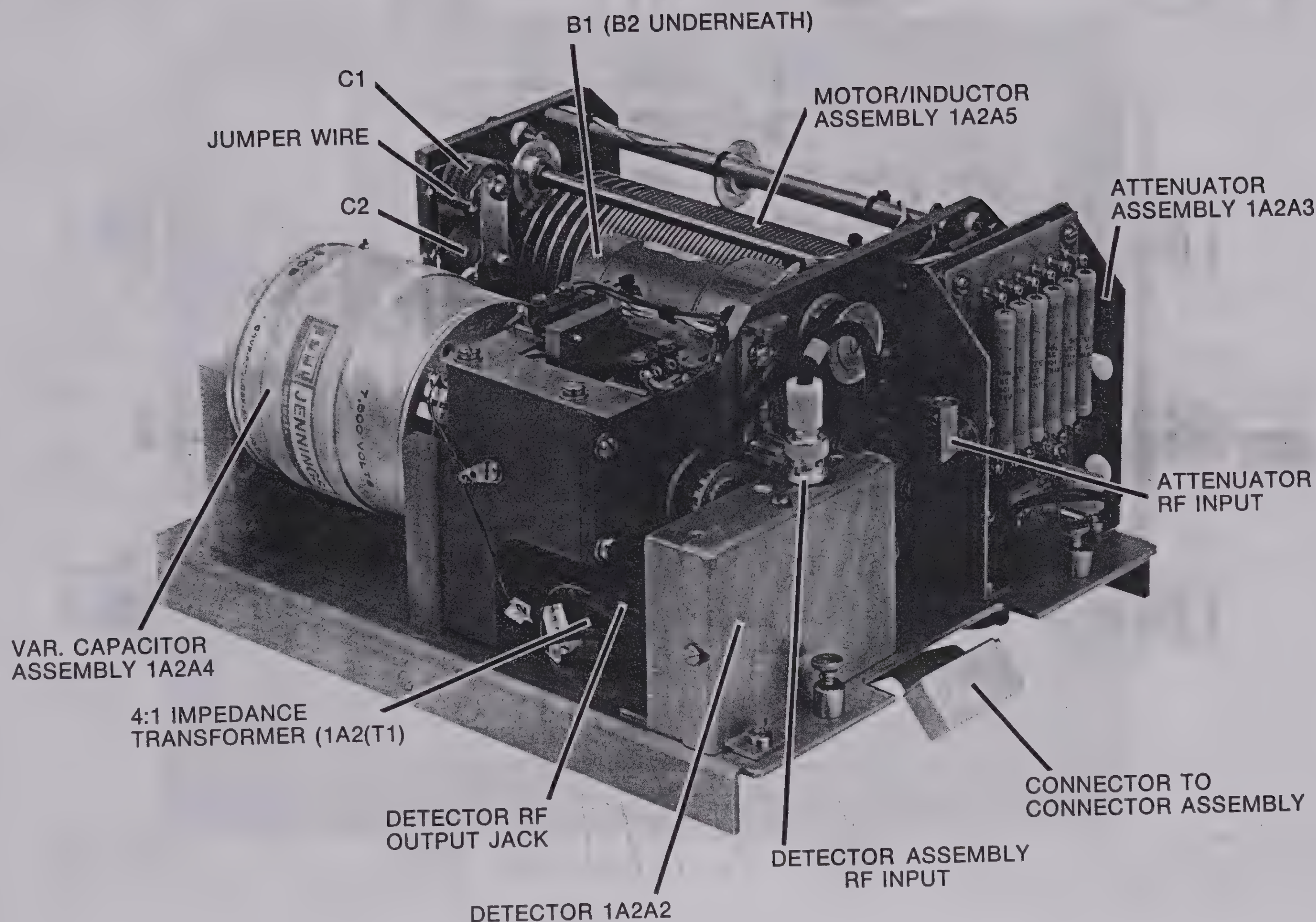


Figure 5.2 Major Component Location

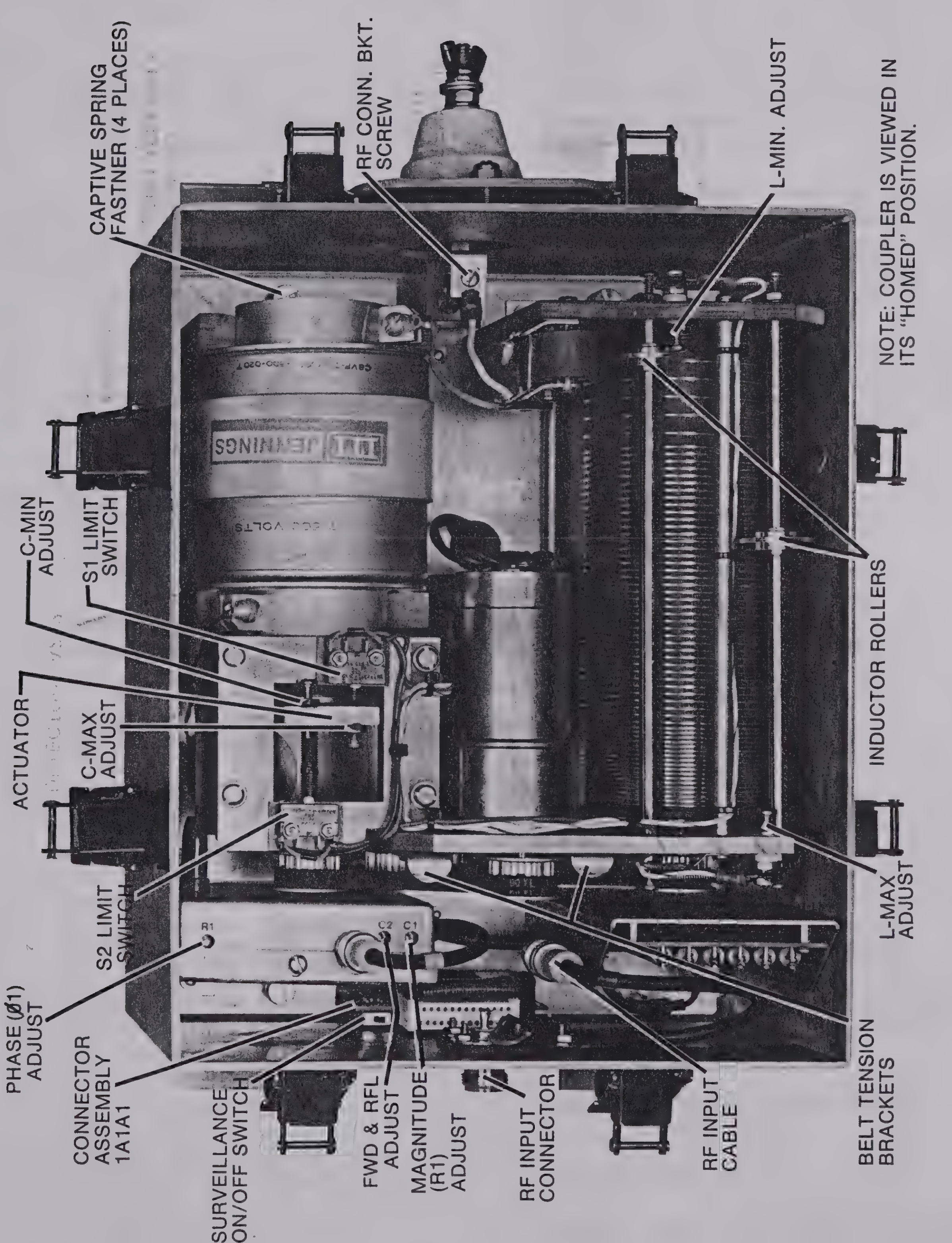


Figure 5.3 Major Component Location

4) Inspect the drive belts for wear and adjust tension if necessary. Tension adjustment will necessitate chassis removal as outlined below.

5) Lubricate the ground rods and the contact point on the rotary inductor with a small amount of cramolin paste.

5.3.3 CHASSIS REMOVAL

The chassis assembly may be removed from the lower enclosure by following the procedure:

1) Loosen the screw on the RF connection bracket that is mounted on the antenna insulator assembly and remove output wire terminal.

2) Unfasten the coaxial RF input cable at the right angle BNC connector on the attenuator assembly.

3) Loosen the 4 captive spring fasteners at each corner of the chassis with a long screwdriver.

4) Remove the ribbon connector from the interface connector board.

5) The chassis may now be lifted straight up and out of the enclosure. (The center support rod of the roller inductor and the rear end of the vacuum variable capacitor make convenient lift points.)

6) Reverse the procedure for reinstalling the chassis assembly into the enclosure.

CAUTION

Make sure that the rollers on the rotary inductor have not been moved off their respective turns.

5.3.4 BELT REPLACEMENT AND ADJUSTMENT

Belt tension for the vacuum variable capacitor and roller inductor is identical. If an adjustment is required or a belt needs replacing, the detector and attenuator assemblies may be temporarily removed for improved belt access.

Belt replacement can be achieved without the need for removing any pulleys. To remove a frayed or otherwise defective belt, loosen the two screws securing the idler bracket and work the belt off the pulleys in a manner similar to changing speed of a pulley/belt type drill press. Likewise, a new belt may be installed without removing any parts.

CAUTION

When removing and installing belts, be sure not to rotate the capacitor or inductor in a direction such that limit switch damage or a "jumped" roller may result.

Belt deflection at the center of the longest run (measured perpendicular to the belt) should be between 1/8-3/16 inch. To adjust belt tension, loosen the idler bracket and press downward on the bracket's tab. Retighten the adjustment screws. If a force gage is available, belt tension may be adjusted by applying 10 ± 1 pounds of force on the idle bracket tab.

5.3.5 CAPACITOR LIMIT SWITCH ADJUSTMENTS

5.3.5.1 C Maximum Adjustment

Loosen the C maximum adjustment screw away from S1. Hand rotate the

capacitor shaft counterclockwise (viewed from the pully end) until the plunger is all the way into the body of the capacitor and the actuator is flush against the capacitor body. Back the plunger out about 1/2 turn and adjust the limit switch adjustment screw to just close the switch. A switch closure may be observed by a distinct clicking sound or by a short circuit reading on an ohmmeter connected between terminal 4 of the switch and chassis ground. Tighten down the adjustment screw and back the plunger out until the switch opens. Rotate the shaft counterclockwise again until the switch just closes. There should be a small amount of play between the actuator and capacitor body of about .05 inches (1-2 mm). Readjust if necessary.

5.3.5.2 C Minimum Adjustment

From the maximum capacitance position (plunger in and C maximum switch just closed), rotate the shaft 23 1/2 turns in the clockwise direction. Set the other adjustment screw to just close the switch. Ohmmeter connections to this switch are also between terminal 4 and chassis ground. (This adjustment is not as critical as that for the C maximum limit.)

5.3.6 INDUCTOR LIMIT SWITCH ADJUSTMENTS

Refer to Figure 5.3 for the following adjustments.

5.3.6.1 L Minimum Adjustment

Connect an ohmmeter between the L minimum screw contact and chassis ground. Hand rotate the inductor clockwise (viewed from the pulley end) until the primary roller, nearest the antenna terminal, strikes the L minimum contact and the ohmmeter reads a short. Note the distance between the roller and the end of the wire on the coil form. About 5 cm (2 inches) of wire should remain on the form. If necessary, adjust the screw contact for this distance. This adjustment is very important, as too little distance may cause the roller to leave the wire and too great a distance will increase the minimum value of inductance and prevent tuning at the higher frequencies. The secondary roller should be 20 turns down from the primary roller.

5.3.6.2 L Maximum Adjustment

Connect the ohmmeter between the L maximum screw contact and chassis ground. Rotate the inductor counterclockwise until the secondary roller strikes the L maximum contact and the ohmmeter reads a short. About one turn of wire should remain on the coil. This adjustment is not as critical as the L minimum adjustment. With the secondary roller at its L maximum limit, the primary roller should be on the last active turn before the more closely spaced shorted turns section.

5.3.7 BALL GAP ADJUSTMENT

Refer to Figure 5.4 for this adjustment. The gap between the acorn nut on the antenna terminal stud and the acorn nut on the grounded bracket, should be adjusted to approximately 3 mm (.125 inches). The gap clearance is adjusted by raising or lowering the screw attached to the brackets. This adjustment is best made with the chassis assembly removed from the enclosure.

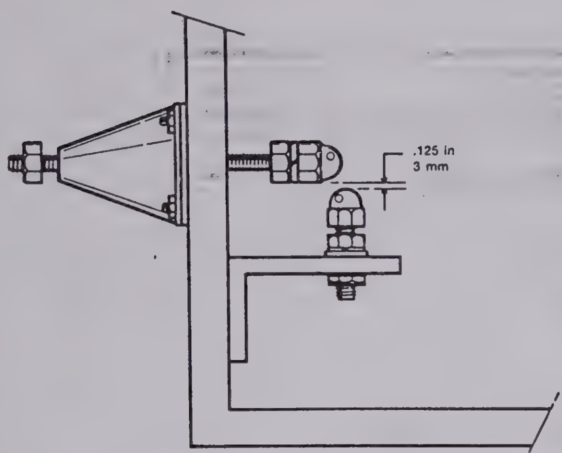


Figure 5.4 Ball Gap Adjustment

5.4 DETECTOR ASSEMBLY ADJUSTMENTS

NOTE

The adjustment of the discriminators in the detector assembly is very critical to the tuning accuracy of the antenna coupler. It should not be necessary to adjust the discriminators unless the assembly has been tampered with or components have been replaced.

5.4.1 ALIGNMENT SET UP

1) Remove the coupler chassis from the coupler case. Disconnect the banana plug jack, the RF connector from the detector assembly and the ribbon cable plug from the bottom of the detector board.
2) Construct a detector assembly cable as shown in Figure 5.5. Connect the banana plug end into the detector, connect the alligator clip to ground, and hook the RF connector up to a 50 ohm load. (It is not necessary to remove the detector assembly from the coupler chassis.)
3) Connect the test set up as indicated in Figure 5.6. Detector assembly outputs are listed in Table 5.1.
4) All adjustments are made while running 15 watts at 15 MHz with the detector assembly terminated into 50 ohms. All measurements are made at the pins of the detector board with a VTVM.

SYMBOL	DESCRIPTION	PINS
$\phi 1$	Phase Discriminator	5,6
R1	Magnitude Discriminator	11,12
FWD	Forward Power Detector	17,18
RFL	Reflected Power Detector	15,16

TABLE 5.1
DETECTOR ASSEMBLY OUTPUTS

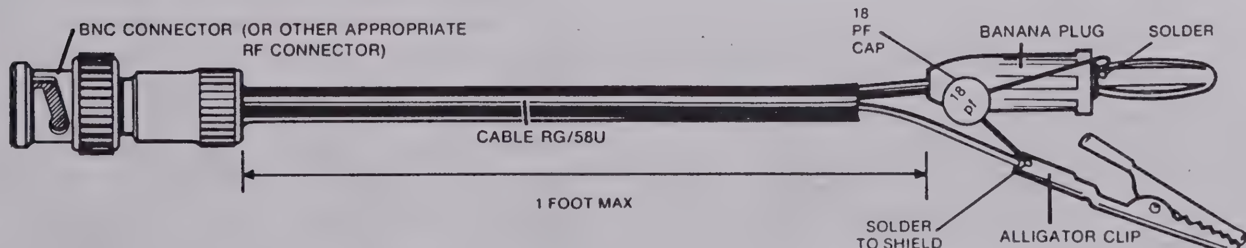


Figure 5.5 Detector Cable Construction

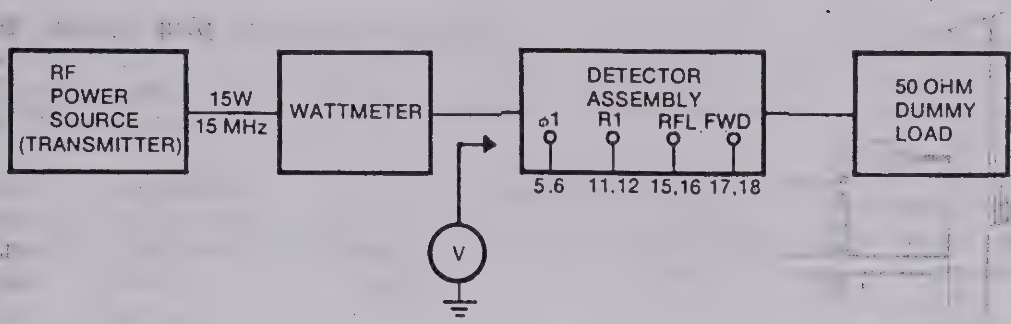


Figure 5.6 Detector Alignment Set-up

5.4.2 PHASE (ϕ 1) DISCRIMINATOR ADJUSTMENT

With the RF on, check pins #5 or 6 (on the detector board) and adjust R1 for a DC null (0 VDC).

5.4.3 MAGNITUDE (R1) DISCRIMINATOR ADJUSTMENT

Check pins #11 and 12 and adjust C1 for a DC null.

5.4.4 FORWARD AND REFLECTED POWER ADJUSTMENT

Measure pin #17 or 18 and adjust C2 for 1.5 VDC output. Check pin #15 or 16 for less than 50 mv, which indicates that the reflected power is properly nulled.

5.4.5 DETECTOR OUTPUTS CHECK

To check the error output accuracy from the detector, a reactive load is needed. To accomplish this, hook the banana plug back into the detector assembly and make sure that the vacuum capacitor is in "homed" position (C maximum). Short to ground the far end of this capacitor (antenna side) and reapply the 15 watts of RF at 15 MHz. Check the four outputs for the following minimum readings: ϕ1 = -1 VDC; R1 = -.25 VDC; FWD = +1.5 VDC; and RFL = +1.5 VDC.

5.4.6 DETECTOR ASSEMBLY REMOVAL STEPS

The detector assembly may be removed from the chassis assembly by following the procedure outlined below:

1) Disconnect the RF input cable on the top of the detector enclosure that goes to the attenuator assembly.

2) Unplug the banana plug that is connected to the 4:1 impedance transformer from the RF output jack on the rear of the detector enclosure.

3) Unplug the 20 conductor ribbon cable from the bottom side of the chassis.

4) Remove the three 8-32 screws and hardware securing the detector assembly to the chassis.

NOTE

Reverse the procedure for reinstalling the detector assembly on the chassis.

5.4.7 DETECTOR ASSEMBLY SPECIFICATIONS

PIN	INPUT OR OUTPUT	FUNCTION	SPECIFICATION
P1-19,20	—	GND	
P1-17,18	Output	V_{FWD} Forward Power	0 to 5 VDC, determined by RF power
P1-15,16	Output	V_{REL} Reflected Power	0 to 5 VDC, determined by RF power
P1-13,14	—	Spare	
P1-11,12	Output	R1 Magnitude Signal	-2 VDC to +2 VDC, proportional to magnitude error - No error = 0 VDC
P1-9,10	Output	R2 Magnitude Reference	0 VDC, used for noise cancellation on R1 line
P1-7,8	Output	$\phi 2$ Phase Reference	0 VDC, used for noise cancellation on d1 line
P1-5,6	Output	$\phi 1$ Phase Signal	-2.5 VDC to +2.5 VDC, proportional to phase error - No error = 0 VDC
P1-3,4	—	Spare	
P1-1,2	—	GND	

5.5 CONTROL BOARD TROUBLESHOOTING

There are no adjustments on the control board. However, because the control board contains all of the active coupler logic circuits, servo amplifiers, and power supplies, it is a likely suspect should coupler trouble develop.

To aid control board troubleshooting, Table 5.2 contains the specifications and input/output functions of all pins on the three edge connectors.

5.5.1 CONTROL BOARD SPECIFICATIONS

1) All interface input logic functions are selected by a closure to ground (<0.5 VDC).

2) All interface logic outputs are open collector and can withstand up to +36 VDC. A circuit completion to ground (<0.5 VDC) selects the particular output function.

3) All internal logic functions are performed with CMOS devices operating from a +8 VDC supply. All CMOS IC output voltages should be either +8 VDC supply or ground, depending on logic state.

5.5.2 CONTROL BOARD TEST POINTS

Nine test points are provided on the control board to aid in troubleshooting (Table 5.3).

TABLE 5.2
CONTROL BOARD PIN INPUT/OUTPUT

PIN	INPUT OR OUTPUT	FUNCTION	SPECIFICATION
P1-1,2	—	GND	
P1-3,4	—	Spare	
P1-5,6	Input	$\phi 1$ Phase Signal	-2.5 VDC to +2.5 VDC, proportional to phase error from detector module. No error = 0 VDC
P1-7,8	Input	$\phi 2$ Phase Reference	0 VDC used for noise cancellation of $\phi 1$ line
P1-9,10	Input	R2 Magnitude Reference	0 VDC used for noise cancellation on R1 line

TABLE 5.2 (continued)

PIN	INPUT OR OUTPUT	FUNCTION	SPECIFICATION
P1-11,12	Input	R1 Magnitude Signal	-2 VDC to +2 VDC, proportional to magnitude error from detector module. No error = 0 VDC
P1-13,14	—	Spare	
P1-15,16	Input	Reflected Power	0 to +5 VDC, proportional to reflected power from detector module
P1-17,18	Input	Forward Power	0 to +5 VDC, proportional to forward power from detector module
P1-19,20	—	GND	
P2-1,2	—	GND	
P2-3,4	—	GND	
P2-5,6	Output	Reflected Power Metering	0 to +5 VDC, proportional to reflected power from detector module
P2-7,8	Output	Forward Power Metering	0 to +5 VDC, proportional to forward power from detector module
P2-9,10	—	Spare	
P2-11,12	Input	Surveillance Tuning	Surveillance tuning enable = GND Surveillance tuning disable = OPEN. (+8 VDC)
P2-13,14	Output	Standby/Fault Status	Standby = continuous GND

TABLE 5.2 (continued)

PIN	INPUT OR OUTPUT	FUNCTION	SPECIFICATION
			Fault = Alternating GND to open circuit at 1 Hz rate
			See 5.5.1 (2)
P2-15,16	Output	Ready Status	Ready = GND
			See 5.5.1 (2)
P2-17,18	Output	Tune In Progress	Tune = GND
			See 5.5.1 (2)
P2-19,20	Output	Key Enable	Key enable = GND
			See 5.5.1 (2)
P2-21,22	Input	Tune Initiate	Tune initiate = momentary GND
			See 5.5.1 (1)
P2-23,24	Input	DC Power Input	Group 001: 11.9 to 14.5 VDC
			Group 002: 22.0 to 42.0 VDC
P2-25,26	Input	DC Power Input	Same as P2-23,24
P3-A	Output	Transistor 1A2Q1, Base	Group 001: 8.5 VDC $\pm$5% (NOT USED)
			Group 002: 20.0 VDC $\pm$10%
P3-1	Output	Transistor 1A2Q1, Collector	Same as P3-1
P3-2	Output	Transistor 1A2Q1, Emitter	Same as P2-23 to 26

TABLE 5.2 (continued)

PIN	INPUT OR OUTPUT	FUNCTION	SPECIFICATION
P3-B	Output	Servo Power Supply (V_{cc}) Attenuator Relay	Group 001: 11.9 to 14.5 VDC Group 002: 20.0 VDC $\pm 10\%$
P3-C	Input	Limit Switch, L Maximum	L at maximum = GND Otherwise = +8 VDC Logic Supply
P3-3	Input	Limit Switch, L Minimum	L at minimum = GND Otherwise = +8 VDC Logic Supply
P3-D	Input	Limit Switch, C Minimum	C at minimum = GND Otherwise = +8 VDC Logic Supply
P3-4	Input	Limit Switch, C Maximum	C at maximum = GND Otherwise = +8 VDC Logic Supply
P3-E, F, H, J, K, L, 10	—	GND	
P3-5	Output	Attenuator Relay	Attenuator in = GND Attenuator out = OPEN See 5.5.1 (2)
P3-6	Output	L Servo, Run to Minimum	Logic 0 < 1.5 VDC Logic 1 > V_{cc} -1.5 VDC See P3-B May have variable pulse width deter mined by error signal on P1-11,12 +.13VDC causes 50% duty cycle output.

TABLE 5.2 (continued)

PIN	INPUT OR OUTPUT	FUNCTION	SPECIFICATION
P3-9	Output	C Servo, Run to Minimum	Logic 0 < 1.5 VDC Logic 1 > VCC-1.5 VDC May have variable pulse width determined by error signal on P1-5, 6. - .10 VDC causes 50% duty cycle output.

TABLE 5.3
CONTROL BOARD TEST POINTS

TEST POINT	FUNCTION	SPECIFICATION
TP1	VSWR < 2:1	+8V when the voltage on the Reflected Power input (J1-15,16) is less than 10% of the voltage on the Forward Power Input (J1-17,18); 0V otherwise.
TP2	RF Present	+8V when the voltage on the Forward Power input (J1-17,18) exceeds .37V ± 10%; 0V otherwise.
TP3	$\overline{\text{L HOME}}$	0V when the Inductor is homing; +8V otherwise.
TP4	$\overline{\text{C HOME}}$	0V when the Capacitor is homing; +8V otherwise.
TP5	$\overline{\text{FORCE}}$	0V when the Inductor is homing; 8V otherwise.
TP6	Servo Enable	+8V when Servomotors are enabled; 0V otherwise.
TP7	Servo Oscillator	Triangular Waveform, 4V P-P, 300 Hz frequency. High point 4 VDC, low point 0VDC. Signal present only when TP2 is at +8VDC (RF present).
TP8	-5 VDC	-5 VDC ± 10%; present only when TP2 is at +8 VDC (RF present).
TP9	+8 VDC	Logic supply; +8VDC ± 5%.
E2	Input Power, Vcc	Group 001: 11.9 to 14.5 VDC Group 002: 20.0 VDC ± 5%

5.5.3 CONTROL BOARD ASSEMBLY REMOVAL STEPS

To remove the control board, follow the procedure below:

1) Disconnect the two ribbon cables and 20 pin PC edge connector from the board.

2) Remove the seven 6-32 screws and washers securing the board to the chassis assembly.

3) Loosen the four 4-40 screws securing the hinge brackets to the chassis.

4) Remove the board by working the two board supports off of the hinge brackets. If necessary, one of the hinge bracket screws may be removed to allow easier board removal.

NOTE

Reverse the procedure for reinstalling the board to the chassis.

5.6 CONNECTOR BOARD ASSEMBLY

There are no adjustments on this board. Troubleshooting should require little more than a visual inspection for continuity or shorts between adjacent tracks. With the ribbon cable disconnected, an ohmmeter may be used to check for shorted bypass capacitors and proper switch operation.

5.6.1 CONNECTOR BOARD ASSEMLBY REMOVAL STEPS

Once the chassis assembly has been removed from the enclosure, the connector board assembly may be removed by the following procedure:

1) Remove the four 6-32 hex nuts and four #6 lockwashers from the studs securing the board to the enclosure.

2) Gently press on the connector from the outside of the enclosure and wiggle the board slightly to slide over the mounting studs.

NOTE

Reverse the procedure for reinstalling the board into the enclosure.

NOTE

Make sure that the gasket is properly positioned over the studs before reinstalling the board. The nuts should be tightened sufficiently and evenly to insure watertight integrity around the gasket.

5.7 ATTENUATOR ASSEMBLY

Because there are few components and no adjustments on the attenuator board, troubleshooting should require only a visual inspection and an ohmmeter check of the power resistors. Resistors R3-R5 are parallel connected and should measure about 17 ohms. Resistors R1, R2 and R6 may be checked individually and should measure about 50 ohms each.

For a quick troubleshooting check, the attenuator can be bypassed entirely by connecting the RF input cable to the detector module RF input. Be careful, as this check removes the 3 dB pad which is designed to protect the transmitter from a high reflected power.

The relay may be checked by applying between 10 and 20 VDC across connector J1, pins 1 and 3. When the relay is energized, the resistance between the RF input (E1) and ground should measure 165 $\pm$20 ohms. When relay voltage is removed, the ohmmeter should indicate an open circuit to ground and a direct short between input terminal E1 and RF output terminal E2.

5.7.1 ATTENUATOR BOARD SPECIFICATIONS

PIN	FUNCTION	SPECIFICATION
E1	RF Input	Provides RF path to Relay Contacts.
E2	RF Output	Provides RF path out of Relay Contacts.
E3	Ground	
J1-1	Relay Coil	Supplies either voltage input or logic ground to relay coil.
J1-2	Ground	
J1-3	Relay Coil	Supplies either voltage input or logic ground to relay coil.

5.7.2 ATTENUATOR ASSEMBLY REMOVAL STEPS

Normally, the attenuator assembly will only require removal when it becomes necessary to replace the roller inductor timing belt or to adjust belt tension.

To remove the attenuator assembly from the chassis, follow the steps below:

1) Disconnect the RF input cable from the right angle BNC connector.

2) Disconnect the 3 pin plug going to connector J1 on the attenuator PC board.

3) Remove the three 8-32 screws and hardware from the chassis bottom. The attenuator assembly may now be repositioned to gain access to the inductor timing belt. If complete assembly removal is necessary, disconnect the attenuator RF output cable from the detector assembly and remove the securing cable clamp from the side of the detector's enclosure.

NOTE

Reverse the procedure for reinstalling the attenuator assembly on the chassis.

5.8 FAULT ISOLATION AND REPAIR

Should a failure occur in the coupler, reference to the following troubleshooting chart should help to isolate the problem. This action should result in less time and effort to repair the unit.

5.8.1 TROUBLESHOOTING CHART

SYMPTOM	PROBABLE CAUSE
No steady fault light at initial power turn on	1) Coupler not properly connected to transceiver. 2) Fault light burned out. 3) Power on reset circuit not working (U14D - control board). 4) Q12 or Q13 defective.
No tune light when tune cycle is initiated	1) Tune light burned out. 2) Tune pulse generator not working (U18D and U24C). 3) Q6 or Q7 defective.
Tune light comes on when tune cycle initiated but tuning elements do not run	1) Motor is defective. 2) Elements already homed but coupler fails to tune (see next symptom). 3) Servo supply voltage, V_{cc}, not present or too low. (Check E2, Group 001, Group 002.) 4) No servo enable signal. (Check TP6, TP3 and TP4 for Logic 1.) 5) No homing signal. (Check TP3 and TP4 for Logic 0.) 6) Pulleys loose on their shafts.
Coupler fails to tune once elements have homed	1) Key enable signal from coupler not present. 2) Q8 or Q9 defective. 3) RF output from transceiver not present or too low. 4) Attenuator faulty. 5) Rollers off coil wire. 6) Excessive RF present on power or control lines.
Vacuum capacitor goes to home and shaft begins to unscrew	1) C Maximum limit switch defective. 2) Switch actuator screw improperly adjusted. 3) Broken wire to switch. 4) Q27-30 defective.
Coupler will not tune below 4 MHz and time delay runs out	1) Inductor forcing function not operating. (Check TP5 for Logic 0.) 2) Series capacitors 1A2A5C1-C2 needs to be inserted.

5.8.1 TROUBLESHOOTING CHART (continued)

SYMPTOM	PROBABLE CAUSE
Couplers goes ready but faults on SSB or CW	1) Antenna or lead-in arcing. 2) Coupler arcing internally. 3) Improper grounding.
Excessive reflected power on all frequencies	1) Detector assembly out of alignment.
Excessive reflected power above 20 MHz	1) Roller inductor L minimum limit actuator improperly adjusted. 2) Vacuum capacitor C minimum limit actuator improperly adjusted. 3) Secondary roller not properly positioned on roller coil. 4) Series capacitor 1A2A5C1-C2 may have to be removed.
Coil rollers hit end of wire and leave track	1) Limit actuator improperly adjusted. 2) U4 defective.
Elements oscillate excessively back and forth near tuning completion	1) Loose or defective belts. 2) Excessive tuning power.
Coupler tunes properly but no FWD or RFL power readings	1) Trouble with transceiver metering circuits. 2) L1 or L2 open if no RFL power. 3) Broken cable wires.
Coupler elements go home, but will not tune or coupler faults before 30 second timer expires	1) External power supply getting excessive RF on lines or dropping out of regulation.
Rotary inductor will not move in a CW and/or CCW direction	1) Q19, Q20, Q21 or Q22 is defective on the control board. 2) Q23, Q24, Q25 or Q26 is defective.
Vacuum capacitor will not move in a CW and/or CCW direction	1) Q27, Q28, Q29 or Q30 is defective on the control board. 2) Q33, Q34, Q35 or Q36 is defective.

TABLE 5.4

CHASSIS/MAIN ASSEMBLY PARTS

DESCRIPTION	PART NUMBER
Limit Switch - 51,52 (capacitor assy.)	600275-616-001
Ribbon Cable, 6 inch	600315-540-005
Ribbon Cable, 3 inch	600315-540-006
Gearmotor, 9.5V (for 12 VDC coupler)	600023-387-001
Gearmotor, 19.1V (for 24 VDC coupler)	600023-387-002
Bushing, Bronze, for variable capacitor	600009-620-002
Leadscrew Shaft (1A2A4C1)	
Inductor, Fixed, 0.7 uH (1A2A5L2)	600316-713-001
Capacitor, Variable, 12-500 pF (1A2A4C1)	600062-317-001
Coil Contact, Inductor Rear Shaft (1A2A5L1)	600252-622-001
Timing Belt (1A2A4C1, 1A2A5L1)	600003-621-005
Inductor, Rotary (1A2A5L1)	600317-713-001
Gasket, Ant. Ins., 3.0 in. dia.	600069-628-001
Gasket, Ant. Ins., 2.5 in. dia.	600072-628-001
Gasket, Connector Board	600075-628-001
Gasket, Cover	600073-628-001
Gasket, Coax Connector	600070-628-001
Pulley, Timing Belt	600078-629-001
Latch, Cover	600246-618-003
Keeper, Latch	600246-618-004
RF Transformer (1A2T1)	600137-512-001
Capacitor, 100 pF, 5 kV (1A2A5C1, 1A2A5C2)	600244-314-003
Spring, Washer (variable capacitor)	600012-246-001
Antenna Insulator Assembly	600323-713-001
Nameplate, Voltage, 12/24 VDC	600517-626-001
Desiccant	600103-205-001

ITT Mackay

2912 Wake Forest Road, Raleigh, North Carolina 27611 U.S.A.
Telephone: (919) 828-4441
W.U. Telex 579451

SECTION 1
GENERAL

1.1 SCOPE

This instruction manual contains information necessary for the installation, operation, maintenance and the repair of the antenna coupler.

1.2 DESCRIPTION

The coupler is remote controlled and is designed to match antennas from 9 foot whips to 150 foot long wires over a frequency range of 1.6 to 30 MHz. The coupler may be configured to operate from either a 12 or a 28 volt system by installation of the appropriate motors and proper strapping connections on the control board. Designed for outside mounting near the antenna, the coupler is mounted in a fully gasketed watertight case.

1.3 SPECIFICATIONS

1.3.1 FREQUENCY RANGE: 1.6 – 30 MHz

1.3.2 ANTENNA MATCHING CAPABILITIES:

Whip,	9 Ft.	1.6 – 30 MHz
Whip,	16 Ft.	1.6 – 30 MHz
Whip,	23 Ft.	1.6 – 30 MHz
Whip,	35 Ft.	1.6 – 30 MHz
Longwire,	50 Ft.	1.6 – 30 MHz
Longwire,	150 Ft.	1.6 – 30 MHz

1.3.3 POWER HANDLING CAPABILITY:

150 Watt Average

1.3.4 INPUT IMPEDANCE: 50 ohm nominal

1.3.5 TUNING ACCURACY: 1.5:1 VSWR max. after tuning

1.3.6 RF TUNE POWER REQUIREMENT:

20 Watt Minimum
50 Watt Maximum

1.3.7 TUNE CYCLE: 30 seconds maximum (Includes Home Time)

1.3.8 STATUS LINES:

Coupler Ready
Excess VSWR (Tune Fault) or Excess Tuning Time Fault
Tune-In Progress

1.3.9 SUPPLY VOLTAGE:

Group 001 – 11.9 to 14.5 VDC

Group 002 – 22.0 to 42.0 VDC

1.3.10 POWER REQUIREMENTS (MAXIMUM):

4 Watts, Coupler Tuned (Surveillance Disabled)
15 Watts, Coupler Tuned (Surveillance Enabled)
40 Watts, Tuning (Average)

1.3.11 DIMENSIONS:

Length	30.5 cm (12 in.)
Width	24.2 cm (9.5 in)
Height	16.3 cm (6.4 in.) – 19.8 cm (7.8 in.) with shock isolation kit

1.3.12 WEIGHT: 9.1 kg (20 lbs.)

1.3.13 TEMPERATURE: -30°C to +65°C

1.3.14 VIBRATION: MIL-STD-810C, Method 514.2, Fig. 6, Curve V (20 to 200 Hz) (with isolators)

1.3.15 SHOCK: MIL-STD-810C, Method 516.2, Figure 2, Procedure 1, (with isolators)

1.3.16 HUMIDITY: 95%, 50°C for 48 hours

1.3.17 ENCLOSURE: MIL-STD-108E, Table II, splash and rain proof, (sealed), designed for exposed installations.

1.4 EQUIPMENT SUPPLIED

1.4.1 COUPLER, ANTENNA, MSR 4020A:

DESCRIPTION	PART NUMBER
Gray, 12VDC	600233-800-005
Gray, 24 VDC	600233-800-006
Olive Drab, 12 VDC	600233-800-007
Olive Drab, 24 VDC	600233-800-008

1.4.2 MANUAL, OPERATION/MAINTENANCE - Part Number 600216-823-002

1.4.3 KIT, ACCESSORY - Part Number 600233-817-009 consisting of the following:

1.4.3.1 Connector, Plug - Part Number 600375-606-014

1.4.3.2 Cable Clamp with Boot - Part Number 600376-606-002

1.4.3.3 Bushing, .437 I.D. - Part Number 600035-643-004

1.4.3.4 Bushing, .562 I.D. - Part Number 600035-643-004

1.4.3.5 Roll, Vinyl Tape - Part Number 600008-108-002

1.4.3.6 Connector, RF Type N (UG-536) - Part Number 600384-606-001

1.5 OPTIONAL EQUIPMENT - NOT SUPPLIED

1.5.1 KIT, SHOCK MOUNTING - Part Number 600233-817-006

1.5.2 CABLE, CONTROL (SPECIFY LENGTH) - Part Number 600069-102-009

1.5.3 ANTENNA WHIP, 9 FOOT - Part Number 600015-398-002 (Use with 1.5.4)

1.5.4 BUMPER MOUNT, MOBILE WHIP - Part Number 600020-398-001 (Use with 1.5.3)

1.5.5 ANTENNA, WHIP, 16 FOOT - Part Number 600015-398-001 (Use with 1.5.4)

1.5.6 SPRING, BUMPER, HEAVY DUTY - Part Number 600020-398-002 (Accessory for 1.5.4) (For 9 Foot Antenna)

1.5.7 ANTENNA, SELF-SUPPORTING, WHIP, 23 Foot - Part Number 600019-398-002

1.5.8 ANTENNA, WHIP, 23 FOOT - Part Number 600019-398-001

1.5.9 MOUNT, LAYDOWN, WHIP, - Part Number 600019-398-003 (use with 1.5.8)

1.5.10 ANTENNA, WHIP, 35 FOOT - Part Number 600018-398-001

1.5.11 MOUNT, BASE, SELF-SUPPORTING, WHIP, - Part Number 600018-398-007 (use with 1.5.10)

1.5.12 MOUNT, BASE, FEEDTHROUGH, WHIP, - Part Number 600018-398-008 (use with 1.5.10)

1.5.13 KIT, ANTENNA, LONGWIRE, 150 FOOT - Part Number 600233-817-007

1.5.14 KIT, SPARE PARTS, DEPOT, COUPLER (12 VDC) - Part Number 600119-700-002

1.5.15 KIT, SPARE PARTS, DEPOT, COUPLER (24 VDC) - Part Number 600119-700-003

1.5.16 CABLE, RF, RG-58A/U (SPECIFY LENGTH) - Part Number 600016-102-001

1.5.17 CABLE, RF, RG-213U (SPECIFY LENGTH) - Part Number 600017-102-001 (Cable recommended for installations longer than 100 feet)

1.5.18 CONNECTOR, RF, TYPE N (UG-21 D/U) - Part Number 600028-606-001 (required with 1.5.17)

1.5.19 KIT, PC BOARD, SPARE (12 VDC) - Part Number 600119-700-004

1.5.20 KIT, PC BOARD, SPARE (24 VDC) - Part Number 600119-700-003

1.5.21 ANTENNA, MOBILE, 16 FT WHIP - Part Number 600018-398-009 (Use with 1.5.22)

1.5.22 KIT, ANTENNA SIDE MOUNT - Part Number 600233-817-008 (Use with 1.5.21)

1.5.23 MOUNT, BASE, FEEDTHROUGH - Part Number 600021-398-001 (Use with 1.5.3 or 1.5.5)

1.5.24 CABLE, CONTROL, PREASSEMBLED - Part Number 600686-540-XXX (complete assembly with connectors for interconnect to MSR 8000 or MSR 6700):

LENGTH	PART NUMBER
10 ft. $\pm$ 3 in.	= 600686-540-001
20 ft. $\pm$ 3 in.	= 600686-540-002
30 ft. $\pm$ 6 in.	= 600686-540-003
40 ft. $\pm$ 6 in.	= 600686-540-004
50 ft. $\pm$ 1 ft.	= 600686-540-005
75 ft. $\pm$ 1 ft.	= 600686-540-006
100 ft. $\pm$ 1 ft.	= 600686-540-007
150 ft. $\pm$ 2 ft.	= 600686-540-008
200 ft. $\pm$ 2 ft.	= 600686-540-009

1.5.26 KIT, COMPREHENSIVE SPARE PARTS (12 VDC) - Part Number 600122-700-001

1.5.26 KIT, COMPREHENSIVE SPARE PARTS (24 VDC) - Part Number 600122-700-002

SECTION 2
INSTALLATION

2.1 GENERAL

This section describes the installation procedure for the antenna coupler. Included within this section are procedures for unpacking, inspection and, if necessary, reshipping.

2.2 UNPACKING AND INSPECTION

Unpack the antenna coupler taking care not to damage the connectors or insulator. Retain the carton and packing materials until the contents have been inspected and checked against the packing list. If there is a shortage or any evidence of damage, do not attempt to use the equipment. Contact the shipper and file a shipment damage claim.

2.3 RESHIPPING

If it should become necessary to return the antenna coupler, a RM (Returned Material) number must first be obtained from the manufacturer. This number must accompany the returned equipment. When the manufacturer receives the equipment, arrangements will be made for expedicious repair or replacement.

When packing the coupler for reshipment, special attention should be given to providing enough packing material around the connectors and antenna insulator. Cardboard or other suitable material must be placed around the unit to protect against damage.

NOTE

To protect against damage, it is recommended the Capacitor Element be positioned at the "HOME" position (maximum capacitance) prior to transporting. This may be accomplished by turning off power to the unit after the element has homed during a tune cycle, or by manually turning the capacitor drive pulley (with all power off!) in a counterclockwise direction until the CMAX limit switch is actuated.

2.4 INSTALLATION

Careful attention to the following installation considerations will result in best coupler performance. Figure 2.1 and 2.2 provide overall coupler dimensions to aid in installation.

2.4.1 INSTALLATION CONSIDERATIONS

1) Antenna Site Location: For optimum characteristics and safety, the antenna should be mounted high enough to clear any surrounding obstructions. The antenna should also be located as far as possible from nearby objects such as power lines, buildings, etc. Typical installations can be seen in Figures 2.3, 2.4, 2.5, and 2.6.

2) Adequate Ground: Provide the best possible RF ground for the radio and the coupler. Use a flat copper strap, 1 inch wide or #6 gauge or larger wire and connect it to the ground terminal at the rear of the transmitter and coupler. Leads to the ground system should be as short as possible.

3) Cable Length: Provide maximum separation between the coupler output and the radio and its associated wiring. The coupler may be mounted up to 200 feet from the radio when RG-213U cable is used. For runs under 100 feet, RG-58 cable can be used. Use the UG-536 B/U RF connector (provided) with the RG-58 cable and a UG-21 D/U connector (accessory, not provided) with the RG-213U cable.

4) Antenna Lead-In: The lead-in from the antenna coupler to the antenna must be insulated for at least 10 kV potential. The lead-in should not run parallel to metal objects which are bonded to the system ground. The tuner should be as close to the antenna as possible and never further away than 3 feet, as this will decrease antenna efficiency.

5) Antenna Compatability: The coupler can be used with 9, 16, 23 or 35 foot whip antennas, as shipped from the factory with no change. However, if a 50 to 150 foot longwire antenna is used, it will be necessary to cut the strap inside the coupler that is across the two 100 pF capacitors.

6) Low Level Modulation: Linear amplifiers with low level modulation will oscillate if the RF power output is radiated or conducted into the low level stages. Evidence of this situation is erratic or excessive power output. This is caused by the coupler and the antenna being too close to the transmitter and/or inadequate RF grounds.

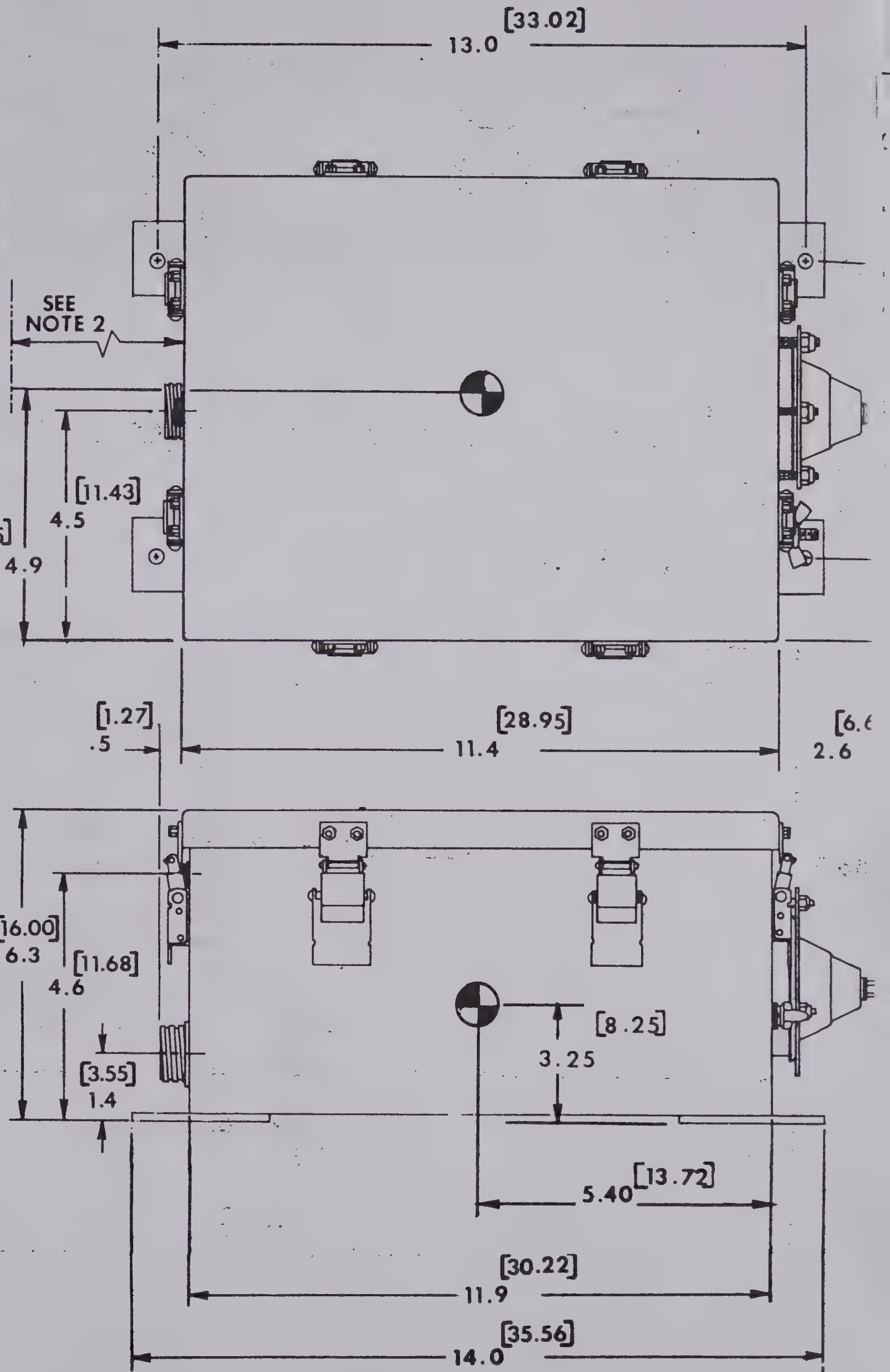
7) Coupler Mounting: The coupler can be bolted to mounts at the base of the antenna in any position with four #10 bolts. Make sure that the ground strap going to the grounding lug of the coupler is adequate and secure. If the coupler is to be subjected to severe shock and vibration, it must be mounted on the optional shock mounting plate, Figure 2.2. The optional isolators supplied are "all attitude" type, that is the coupler may be mounted in any plane although it is recommended that the horizontal position be used if possible, as shown in Figure 2.2.

8) Weatherproofing Cables: After all connections are made to the coupler, completely tape both cable connectors with coax sealant that is supplied. The application procedure is to roll off approximately 6 inches of plastic tape, remove the backing, wrap starting at the cable outer covering and work toward the fitting with 1/2 tape width overlap. After wrapping, gently knead to form a smooth surface and to force out any air.

2.4.2 REMOTE CONTROL CABLE FABRICATION

The following material is required and supplied for fabricating the control cable:

1) Connector, Assembly (P2) - 1 each


[33.02]
13.0
SEE
NOTE 2
[12.45]
4.9
[11.43]
4.5
[1.27]
.5
[28.95]
11.4
[6.6
2.6
[16.00]
6.3
[11.68]
4.6
[3.55]
1.4
[8.25]
3.25
5.40
[13.72]
[30.22]
11.9
[35.56]
14.0

NOTES: 1. DIMENSIONS IN INCHES & [CM].
2. RESERVE 6" FROM ENCLOSURE FOR CONNECTOR AND CABLE BEND.
3. UNIT WEIGHT 20 LBS. [9.1 KG]

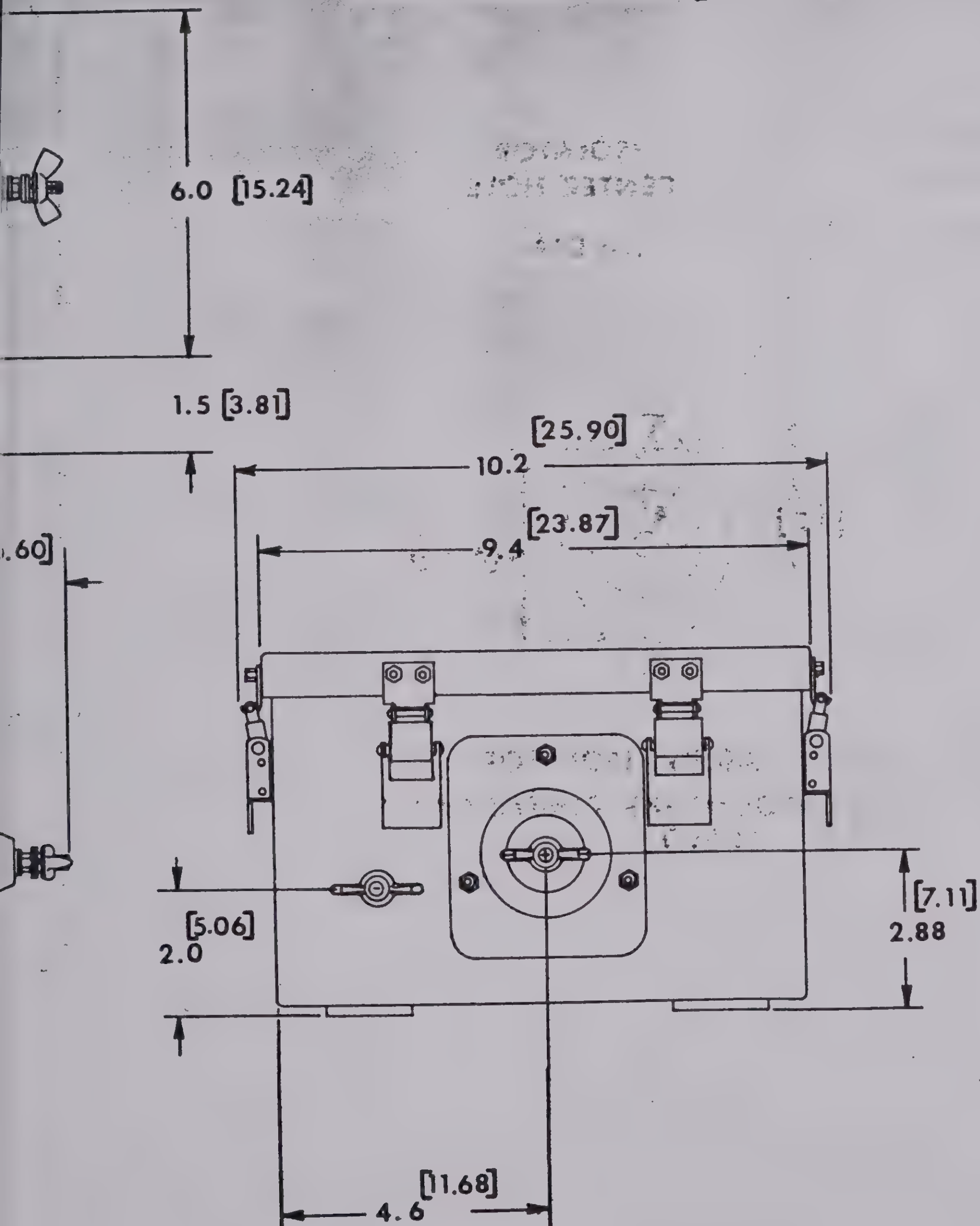


Figure 2.1 Dimensions

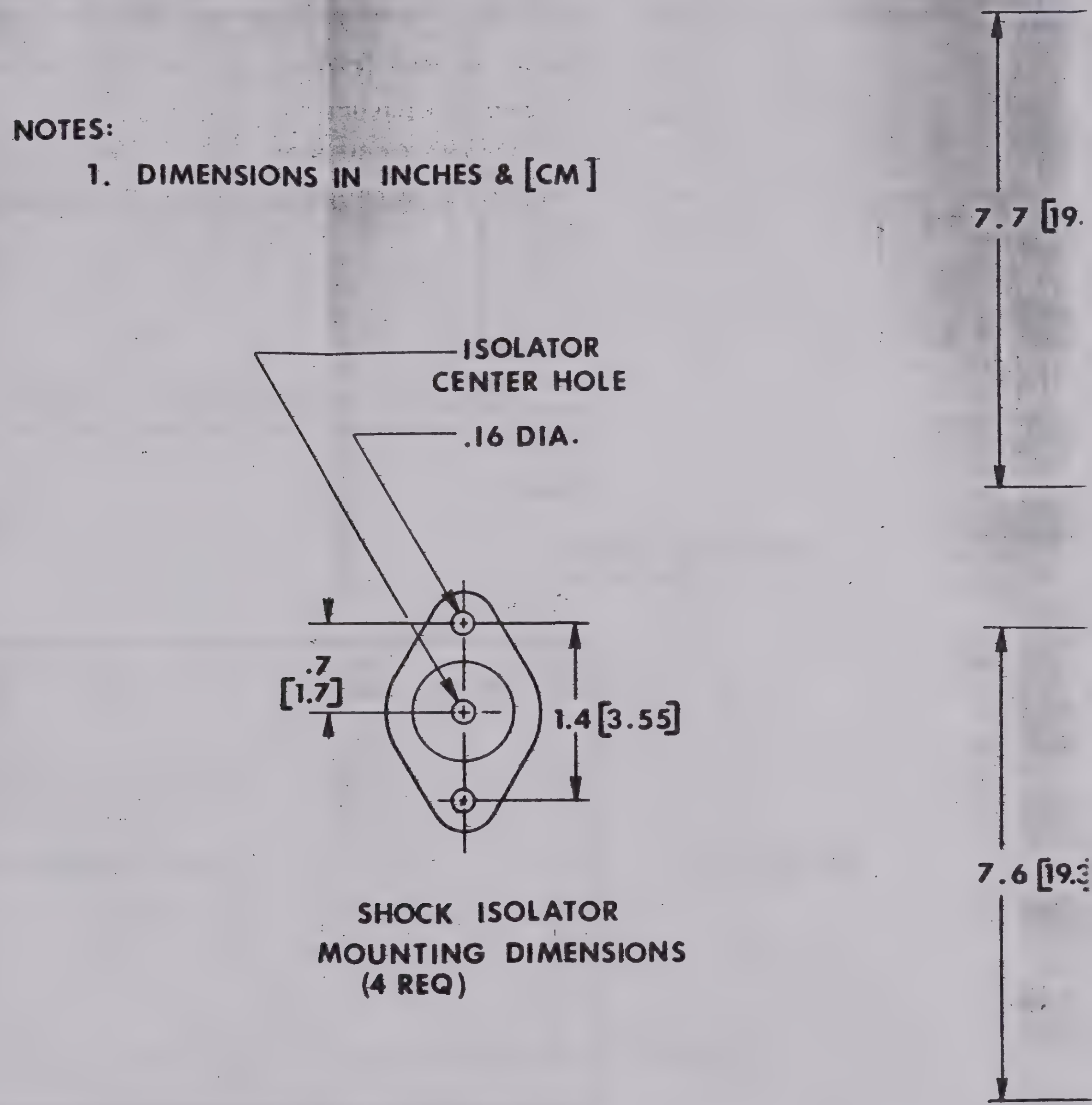
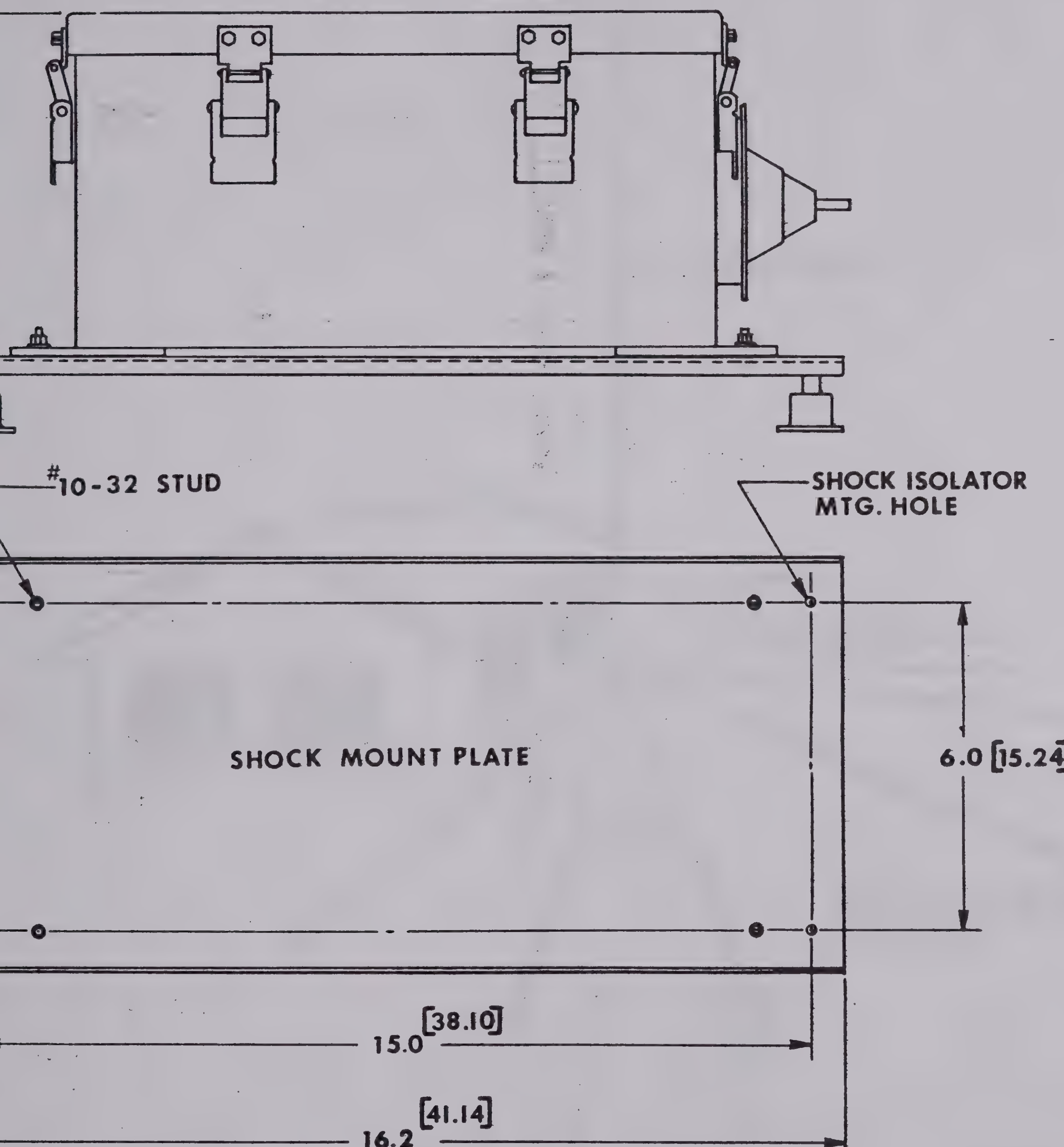


Figure 2.2 Shock Mounting Plate



#10-32 STUD
SHOCK ISOLATOR MTG. HOLE
SHOCK MOUNT PLATE
6.0 [15.24]
15.0 [38.10]
16.2 [41.14]

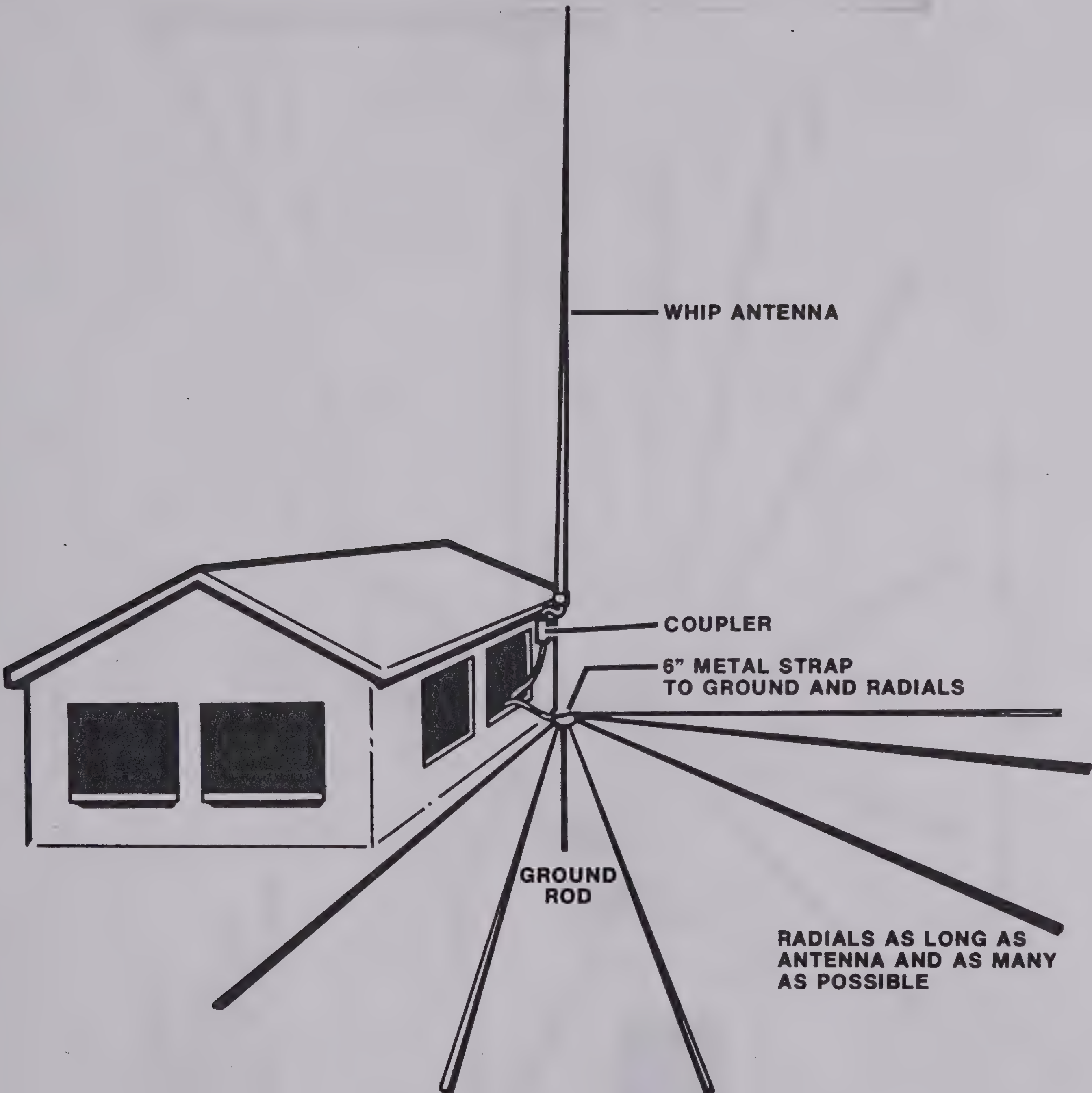


Figure 2.3 Typical Whip Antenna Installation

RADIALS AT LEAST AS LONG AS
ANTENNA; AS MANY AS POSSIBLE.
RADIALS MAY BE BURIED. 10
FOOT METAL (POROUS BRONZE)
GROUND ROD TIED TO RADIAL SYSTEM.
MAXIMUM RADIATION PATTERS ARE
ORDINARILY BROADSIDE TO THE ANTENNA

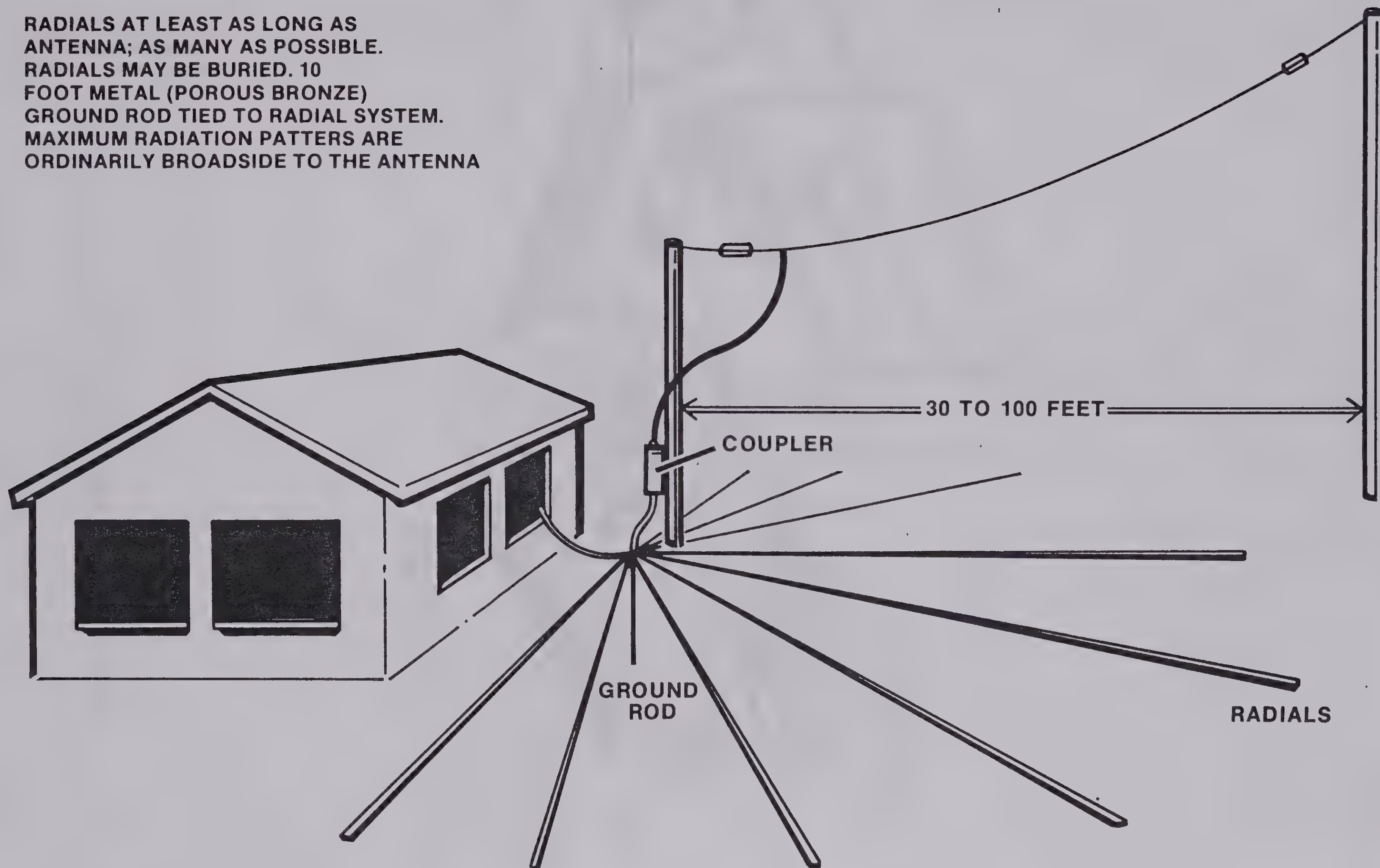


Figure 2.4 Typical Longwire Antenna Installation

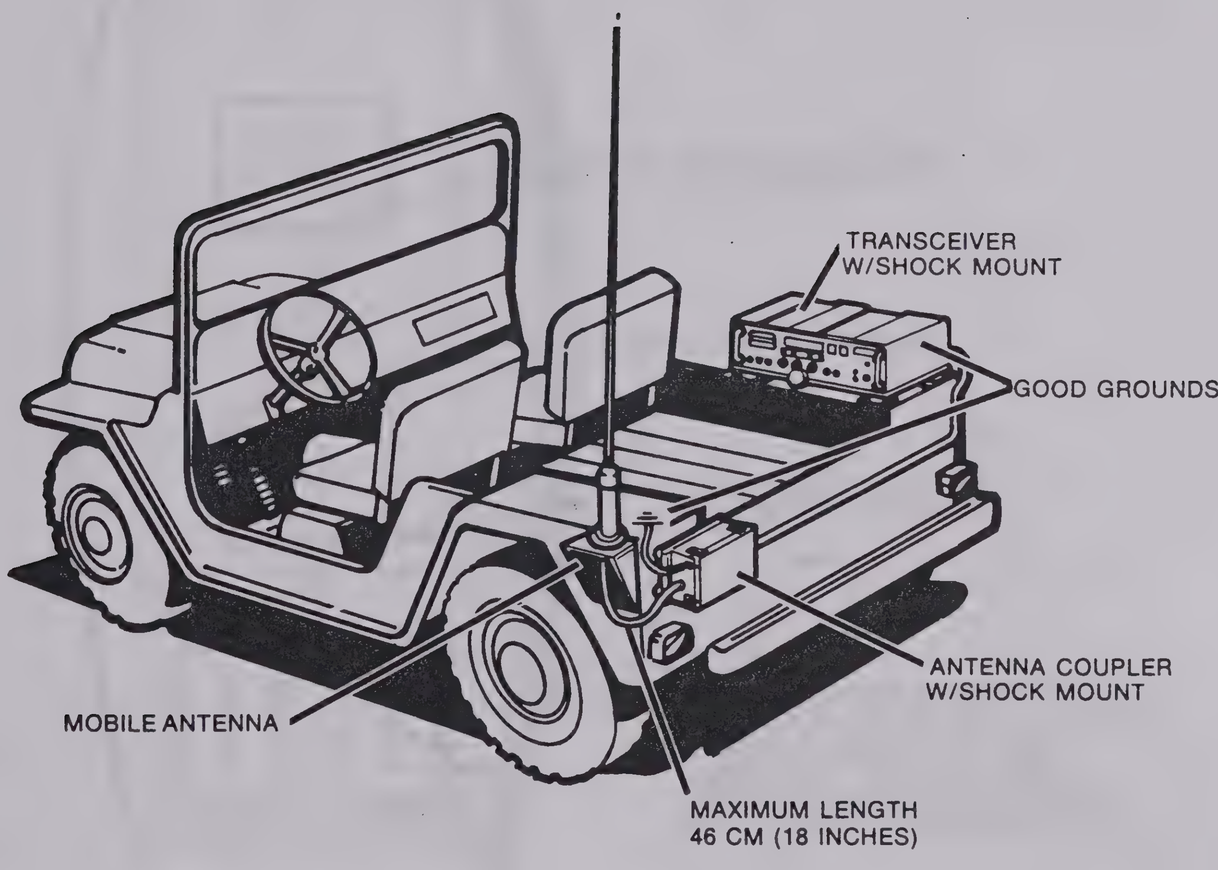


Figure 2.5 Typical Vehicle Installation

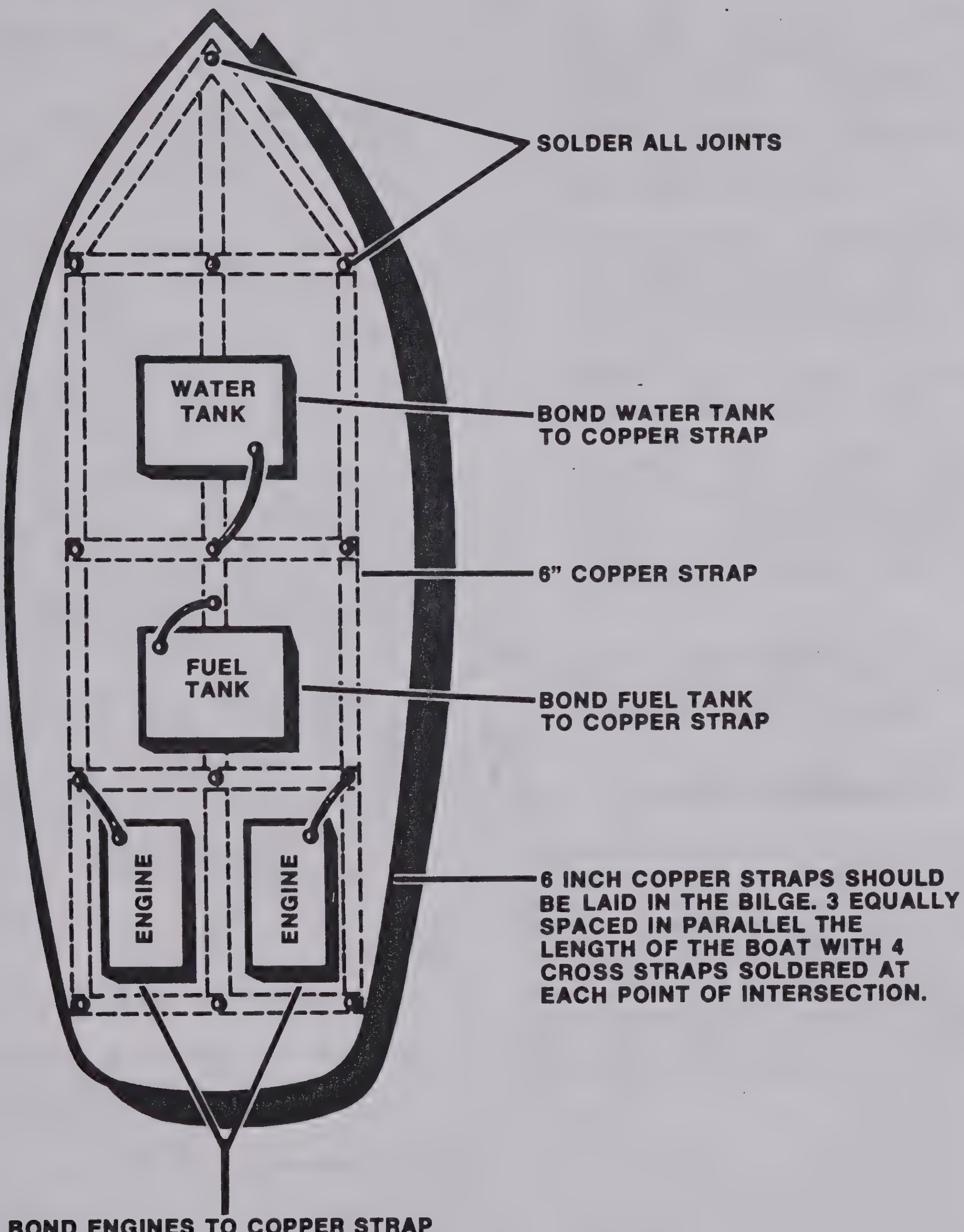


Figure 2.6 Typical Ground/Counterpoise Installation

2) Clamp, Cable
3) Bushing, Clamp

2.4.2.1 The following material is required but not supplied for fabricating the control cable:

1) Solder
2) Cable, 12 conductor, #18 AWG, shielded and jacketed (optional item 1.5.2)
3) Wire, insulated, 2 1/2 inches long, #18 AWG
4) Vinyl Tape
5) RTV Sealant

2.4.2.2 It is recommended that the control cable for the coupler be purchased from the manufacturer. However, a shielded PVC jacketed cable with at least 12 #18 AWG wires can be substituted. Use Table 2.1 to fabricate the cable.

1) Strip and cut cable ends to dimensions shown in Figure 2.7.

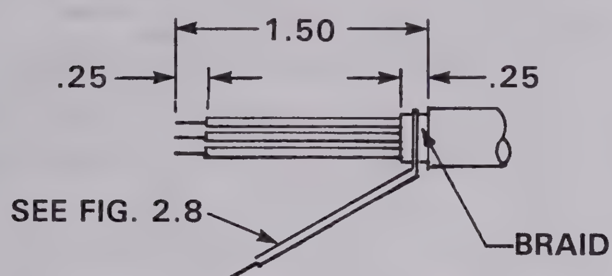


Figure 2.7 Cable End Preparation

2) Prepare a length of #18 AWG insulated wire as shown in Figure 2.8.

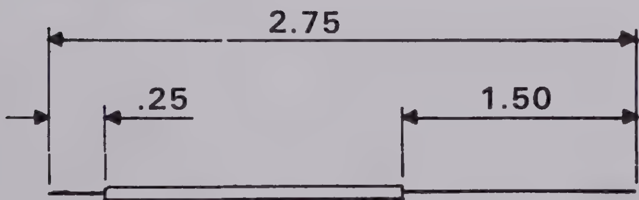


Figure 2.8 Braid Ground Wire

3) Wrap braid ground wire (longer bared end) completely around exposed braid (see Figure 2.7) and solder. Be careful not to overheat and melt insulation.

4) Tin ends of all wires.

5) Slide clamp and bushing over end of cable. Remove back and collar from connector (see Fig. 2.9) and slide over cable.

6) Solder wires into connector using information in Table 2.1.

7) Reinstall and tighten collar, back, bushing and clamp (application of silicone grease to threaded parts will facilitate assembly). Tighten screws on cable clamp.

8) After installation, be sure to weatherproof connection as discussed in 2.4.1, paragraph 8.

2.5 POWER REQUIREMENTS

The antenna coupler is manufactured to operate in two voltage ranges. Group 001 coupler can operate from 11.9 to 14.5V and Group 002 coupler can operate from 22 to 42 VDC. To change from one group to another requires that the DC motors be changed and some strapping be performed on the control PC board.

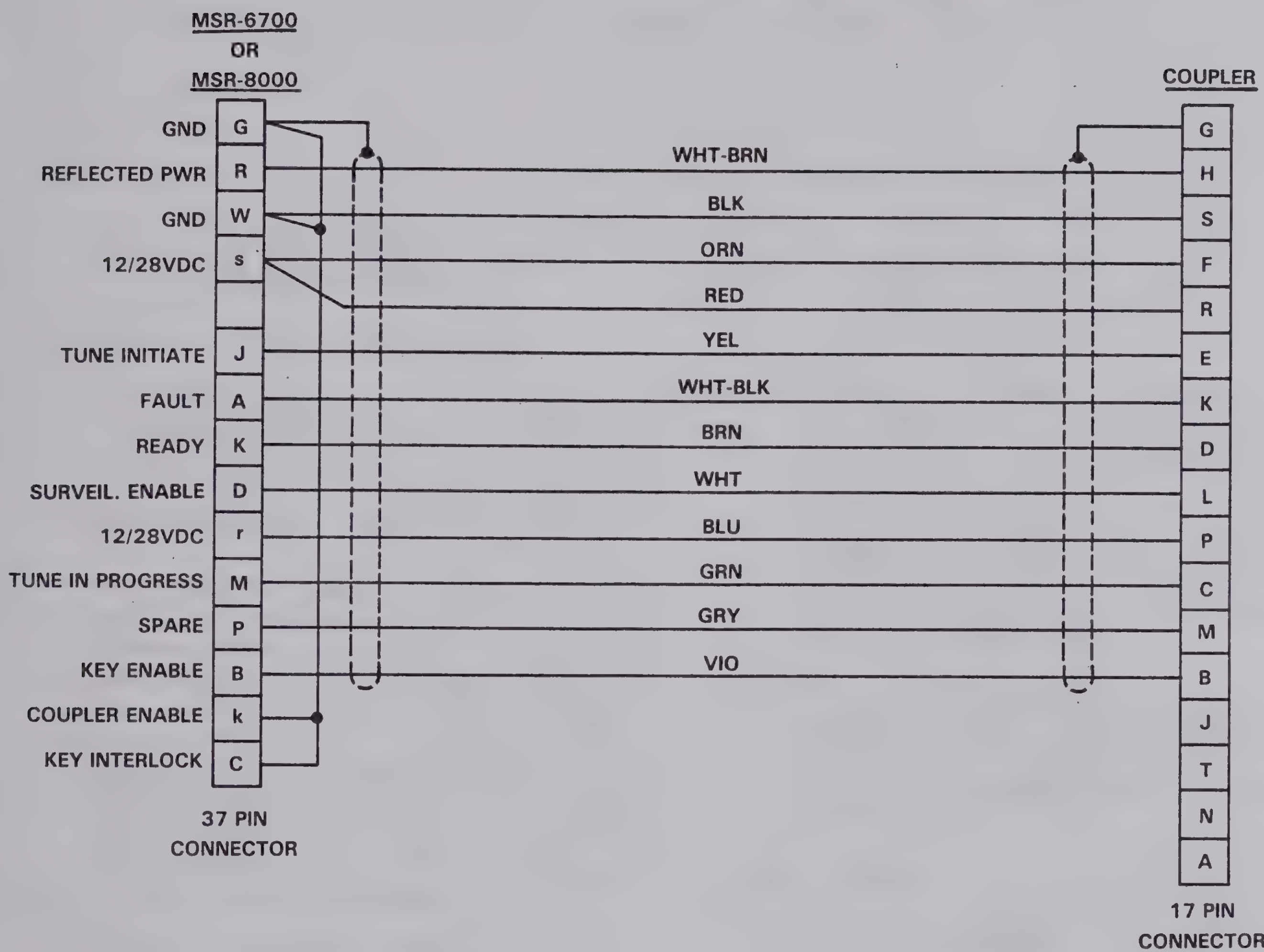


TABLE 2.1

COUPLER CONTROL CABLE

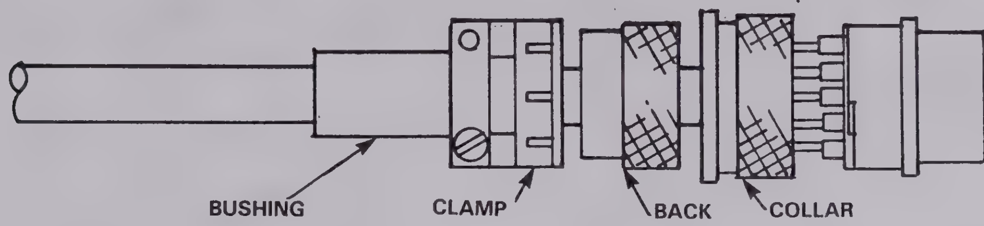


Figure 2.9 Control Cable Connector Assembly

2.6 TESTS AFTER INSTALLATION

2.6.1 ANTENNA CONSIDERATIONS

The input impedance of an antenna is influenced by many factors, such as earth conductivity, height above ground, effects of nearby conductors and dielectrics, and antenna length.

The antenna coupler contains two parallel connected 100 pf ceramic transmitting capacitors which are mounted on the rear support plate of the roller inductor. These capacitors, designated C1 and C2, may be connected in series with the output lead to the antenna and will effectively reduce the maximum value of series capacitance that is required to tune certain antennas.

2.6.2 INSTALLATION CHECKS

1) Whip Antennas: The coupler will tune whip antennas without the need for series capacitors C1 and C2. These capacitors should be shorted by a small piece of buss wire soldered across the capacitors.

NOTE

The coupler as shipped from the factory is connected for whip antenna operation (that is with the capacitors short circuited).

2) Longwire Antennas: Depending on the length and mounting configuration of longwire antennas, the insertion of C1 and C2 will normally be required. The small jumper wire across C1 and C2 need only be cut or removed to insert the capacitors in series with the output lead.

3) It is recommended that tuning be checked on the desired frequencies to ensure whether or not C1 and C2 are required for a given antenna.

2.6.3 TESTS

NOTE

It is assumed that the coupler control will come from its companion transceiver or another 125 watt transmitter with an external control head.

When the system installation is complete, perform the following tests:

1) Connect a wattmeter and a 50 ohm, 100 watt dummy load to the transceiver RF output.

2) Turn on the transceiver. The FAULT light should be illuminated (steady, non blinking).

3) Place the MODE switch on the transceiver in the AME or AM position. Key the microphone, and check forward power on several frequencies. The AME power output should be approximately 35 watts.

4) Press the TUNE button. The NOT TUNED light should be illuminated and the power output should be about 35 watts. Turn off the transceiver power switch.

5) Remove the dummy load and connect the wattmeter between the transceiver RF output and the RF input to the antenna coupler. Turn the transceiver power switch on. Depress the TUNE button. The reflected power on the wattmeter should be less than 10 watts and the panel meter should indicate a reading on both FWD and RFL switch positions. The reflected power indicated on the wattmeter should change and finally drop to near zero. At this time, the READY light should be illuminated.

6) With the MODE switch in the AME position, key the transmitter. Check forward and reflected power to determine VSWR.

7) Check transceiver/coupler operation on all desired frequencies and note the reflected power.

2.6.4 DESICCANT INSPECTION

The coupler is protected from humidity by a rechargeable/replaceable desiccant cartridge. The cartridge has a humidity indicator located on the exposed side. The indicator should be inspected at least once every six months or, more often during adverse weather or humidity conditions.

When the center dot of the indicator turns from blue to pink, the desiccant cartridge must be replaced or recharged. Proceed as follows to recharge the desiccant:

a) Remove the cartridge from the antenna coupler.

b) Place the desiccant cartridge into an oven.

c) Heat at 300°F (149°C) for two or three hours or, until the indicator returns to its normal blue color.

d) After cooling, replace the desiccant cartridge. Ensure that the cartridge is securely tightened.

SECTION 3
OPERATION

3.1 GENERAL

This section contains information and instructions required for proper operation of the antenna coupler when used with its companion trans ceiver or exciter. Refer to the transceiver's/exciter's technical manual for a complete technical description of coupler's operation.

3.2 OPERATING CONTROLS

The following controls and indicators are located on the front panel of the companion transceiver or exciter.

3.2.1 TUNE: Depressing this button initiates a tuning cycle. A momentary depression of this button is the only action required.

3.2.2 FAULT: This light is illuminated for the following conditions:

1) When the transceiver/exciter is initially turned on, a steady, non-blinking light comes on.

2) When the time delay runs out (approximately 30 seconds after initiation of a tune command) the light will blink.

3) Anytime the VSWR exceeds 2:1, except during a tuning cycle, the light will blink.

3.2.3 NOT TUNED: This light is illuminated only during a tuning cycle or when the VSWR is greater than 2:1.

3.2.4 READY: This light is illuminated after a tuning cycle has been completed and the coupler has tuned to a VSWR less than 2:1.

3.2.5 TX POWER SWITCH

1) FWD: Indicates relative forward RF power at the input to the antenna coupler.

2) RFL: Indicates relative reflected RF power at the input to the antenna coupler. A null or low reading when transmitting indicates that the antenna is correctly matched to the transceiver.

3.3 GENERAL OPERATING PROCEDURES

Refer to the transceiver/exciter technical manual for detailed operating procedures.

3.3.1 MANUALLY INITIATED TUNE CYCLE

Momentarily depressing the TUNE button on the companion transceiver/exciter will cause the coupler to tune. After tuning is complete, the green READY light will be illuminated and the unit is ready for operation.

3.3.2 AUTO-TUNE CYCLE

If the auto-tune feature has been selected in the companion transceiver/exciter, the coupler will automatically tune whenever the channel has been changed or if the frequency has been changed by 10 kHz

or more. Note, however, the coupler does not begin the tune cycle until the Transceiver/Exciter is keyed.

3.3.3 VSWR RETUNE CYCLE

Selecting this feature at the companion Transceiver/Exciter will cause the coupler to tune automatically if the VSWR sensed by the coupler exceeds 2:1 during transmission.

3.3.4 SURVEILLANCE TUNING

The surveillance feature may be enabled at the companion Transceiver/Exciter or by turning on switch S1 on the Connector Board Assembly inside the coupler. When enabled, this feature allows the coupler to retune automatically for small changes in transmitter frequency and to correct for variations in antenna impedance. The coupler does not actually enter a tune cycle, but rather enables the element servomotors so that they may track the discriminator error signals. The coupler must be in a READY state (green lamp illuminated) and RF power must be transmitted for the surveillance feature to operate.

If a frequency or antenna impedance change is made that is out of the surveillance tuning range, the red FAULT lamp will flash and the coupler must be retuned through a normal tune cycle.

SECTION 4
THEORY OF OPERATION

4.1 GENERAL

The automatic antenna coupler is designed to be used with the 100-150 watt class of transmitters or transceivers having a standard 50 ohm output impedance. The operation of the coupler is completely automatic and includes all network tuning, control, and monitoring functions.

4.2 SUBASSEMBLIES

The antenna coupler consists of several assemblies as described below and shown in Figure 4.1.

4.2.1 ENCLOSURE (1A1): The enclosure provides a watertight, protective environment for housing the coupler.

4.2.2 INTERFACE CONNECTOR ASSEMBLY (1A1A1): The interface connector assembly provides DC power and control line interconnections between the external control cable and coupler circuitry. A miniature slide switch for enabling the surveillance tuning feature is a part of this assembly.

4.2.3 ANTENNA INSULATOR ASSEMBLY (1A1A2): The antenna insulator assembly provides a mechanical and electrical connection between the coupler and antenna.

4.2.4 CHASSIS ASSEMBLY (1A2): The chassis assembly provides the required mounting surfaces for the other electrical and mechanical assemblies.

4.2.5 CONTROL BOARD (1A2A1): The control board contains all of the active coupler logic circuits, servo amplifiers, and the related power supply elements.

4.2.6 DETECTOR ASSSEMBLY (1A2A2): The detector assembly contains the phase discriminator, magnitude discriminator, and forward and reflected power detectors.

4.2.7 ATTENUATOR ASSEMBLY (1A2A3): The attenuator assembly provides a series 3 dB pad and switching relay to limit impedance variations during the tuning cycle.

4.2.8 VARIABLE CAPACITOR (1A2A4): The variable capacitor assembly consists of the vacuum variable capacitor, its support and mounting brackets, limit switches, switch actuator, and associated hardware.

4.2.9 MOTOR/INDUCTOR ASSEMBLY (1A2A5): The motor/inductor assembly consists of the roller inductor and its limit switches, drive motors, associated belts, pulleys and idlers and the mounting surface for C1, C2, and L2.

4.3 TUNING NETWORK

The antenna tuning network consists of a series C, shunt L configuration with an auxilliary capacitor which may be inserted in series with the antenna under certain conditions. A block diagram of the antenna coupler is shown in Figure 4.2.

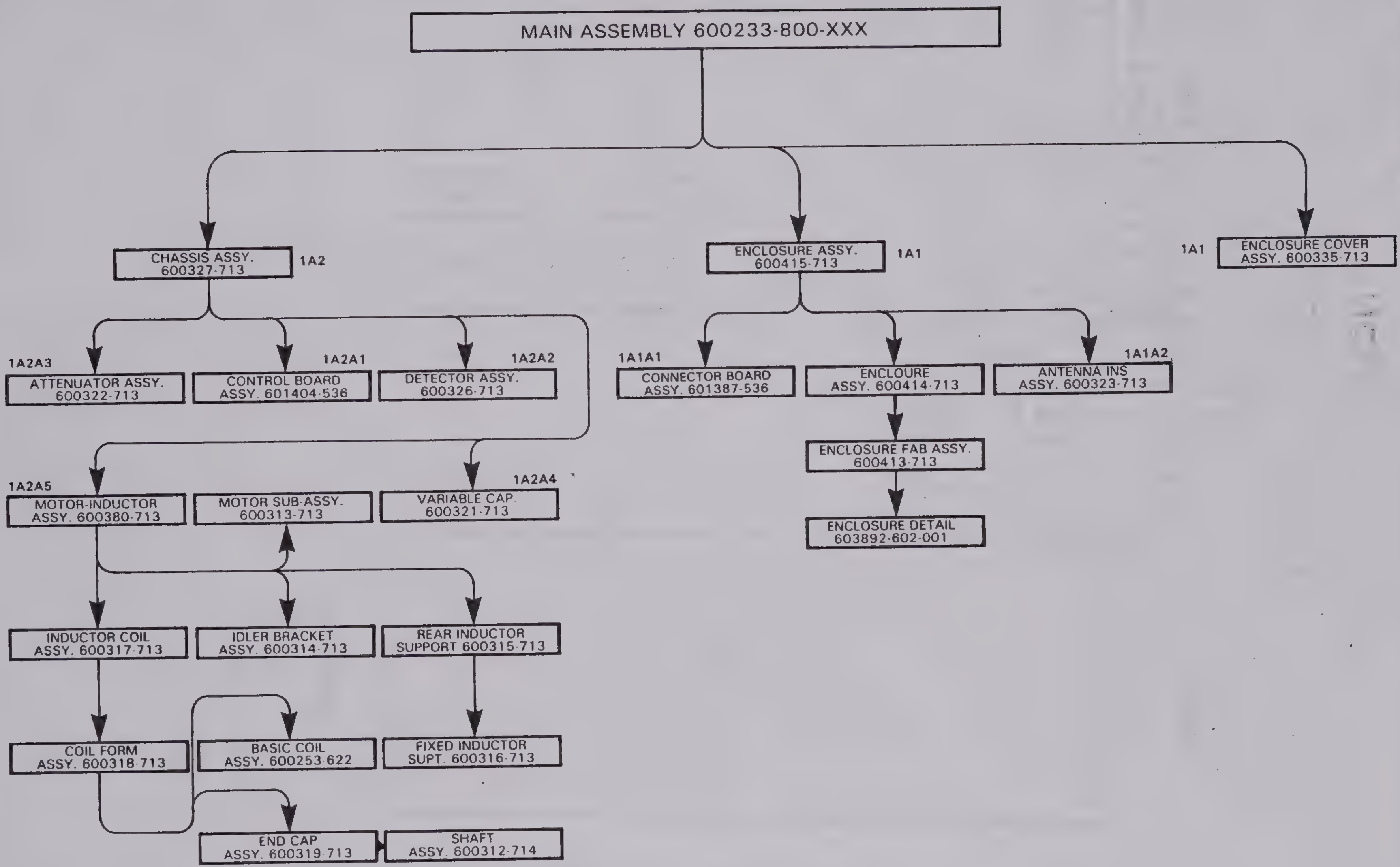


Figure 4.1 Subassemblies

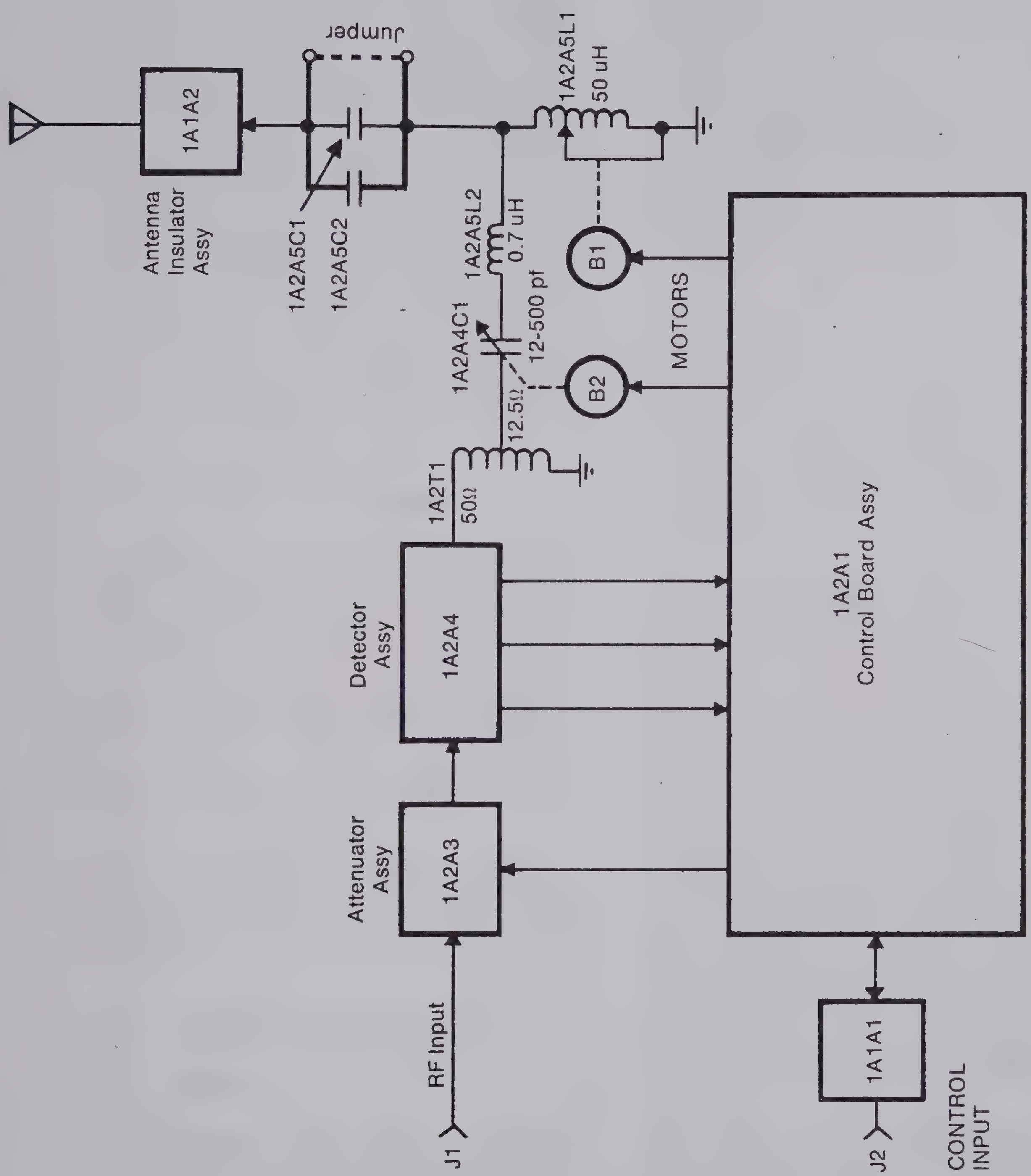


Figure 4.2 Block Diagram

C1, the series element, is a 12-500 pf vacuum variable capacitor, while L1, the shunt element, is a 0.1-50 µH variable inductor. The variable inductor has two tracking roller contacts to prevent possible self-resonances. C1 and C2 are parallel connected 100 pf ceramic transmitting capacitors that may be hard-wired in series with the antenna when using longwire type antennas. Fixed inductor L2 is a small 0.7 µH coil in series with C1 and has the effect of making the value of C1 "look" much larger at resonance. A 4:1 impedance matching transformer, T1, is used at the input of the network to provide a wider tuning range with the given values of L and C.

4.4 NETWORK CONTROL

The coupler's variable tuning elements are adjusted by two separate servo systems in accordance with the signal outputs from the detector assembly. The phase discriminator output controls the capacitor servo system and the magnitude discriminator output controls the inductor servo system. A power detector is used for metering forward and reflected power samples.

During the tuning cycle, a 3 dB attenuator is switched in series with the RF input to limit impedance variations.

4.5 DETECTOR ASSEMBLY

4.5.1 GENERAL

The detector board (Figure 4.3 and 4.4) (1A2A2) contains the phase (ϕ) discriminator, magnitude or (R) discriminator, and forward and reflected power detectors.

When the antenna has been properly tuned or matched by the reactive elements in the antenna coupler, the coupler will present a purely resistive 50 ohm load to the transmitter. If the antenna is not properly tuned, the impedance at this point may be something other than 50 ohms and either inductive or capacitive. The circuits on the detector board sense these conditions and direct the coupler's tunable elements to achieve a proper match.

4.5.2 PHASE (ϕ) DISCRIMINATOR

The function of the phase (ϕ) discriminator is to sense the reactive component and to provide a proportional DC output to the servo system that will drive the variable capacitor such that the condition is corrected.

The discriminator circuit is constructed such that the antenna current induces a voltage in transformer T1. The combination of C7 and R3 forms a divider which produces a reference voltage at the junction of R4 and R5 which is 90° out of phase with the line voltage. The combination of hot carrier diodes CR1 and CR2, along with R2, serve to limit the amplitude of this reference voltage which would change with power and frequency. The vector sum of the reference voltage and the induced voltage in T1 are detected by CR3 and CR4, filtered by C3 and C4 respectively, and summed in potentiometer R1. R1 is adjusted such that the circuit is perfectly symmetrical.

When adjusted properly, the phase discriminator output on pins 5 and 6 will be at a null (zero volts) when the antenna impedance presents a purely resistive load, as in a tuned condition. If the load is capacitive, a positive output results and

causes the servo system to drive the vacuum capacitor toward maximum capacitance. If the load is inductive, the output is negative and the vacuum capacitor is driven toward minimum capacitance.

4.5.3 MAGNITUDE (R) DISCRIMINATOR

The function of the magnitude (R) discriminator is to sense the resistive component of the line impedance and to provide a proportional DC output to the servo system that will drive the variable inductor to achieve a resistive component of 50 ohms.

The discriminator circuit is constructed such that the antenna current induces a voltage in transformer T2. The combination of C1 and C6 form a divider which produces a voltage sample in phase with, and proportional to, the line voltage. L1 is provided for frequency compensation. This voltage is detected by CR5, peak filtered by C8, and will produce a positive voltage across R11 at the output. L2 is used strictly as a DC return path to ground.

When the load impedance is 50 ohms resistive, the voltage across T2 is twice the amplitude and 180° out of phase with the voltage sample produced by divider C1 and C6. The vector sum of the outputs from T2 and divider C1/C6 is detected by CR7, filtered by C9, and appears as a negative voltage across R12. Thus, when the line impedance is 50 ohms resistive, the positive voltage across R11 and the negative voltage across R12 are equal and opposite and the magnitude discriminator output on pins 11 and 12 will be at a null (zero volts), as in a tuned condition.

If the load impedance is higher than 50 ohms, a lower antenna current will result causing a lower voltage across T2 and less negative voltage across R12. The output from the discriminator will then be positive and cause the servo system to drive the variable inductor toward minimum inductance.

If the load impedance is less than 50 ohms, a higher antenna current will result causing a higher voltage across T2 and more negative voltage across R12. The output from the discriminator will go negative and cause the servo system to drive the variable inductor toward maximum inductance.

4.5.4 FORWARD AND REFLECTED POWER DETECTOR

The function of the power detector is to provide voltage samples of forward and reflected power for metering purposes and for use with the VSWR comparator on the control board.

As with the (R) discriminator, the power detector is constructed such that the antenna current induces a voltage in transformer T3. The combination of C2 and C12 forms a divider which produces a voltage sample in phase with and proportional to the line voltage. The voltage across C12 is in phase and equal in magnitude at 50 + j0 (the tune point) to the voltage developed at pin 1 of T3. These voltages, added vectorially, are rectified by CR8, peak filtered by C13, and appear as a positive DC voltage proportional to the forward power on pins 17 and 18.

The voltage across C12 is 180° out of phase with, and equal in magnitude to, the voltage developed at pin 2 of T3. These voltages are

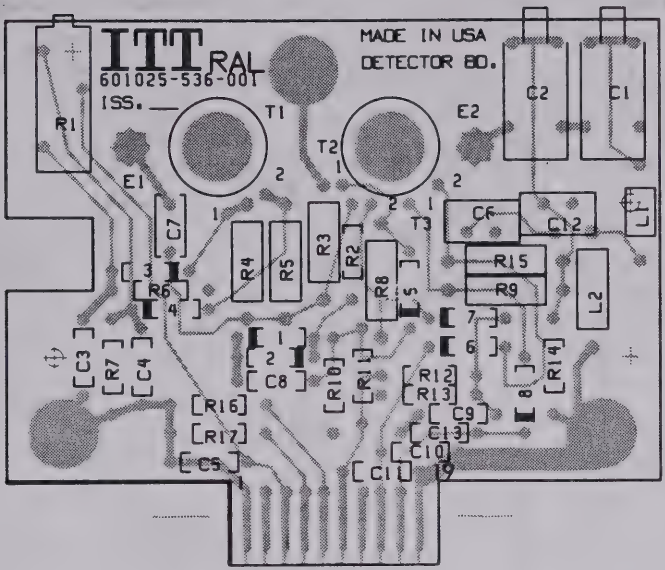
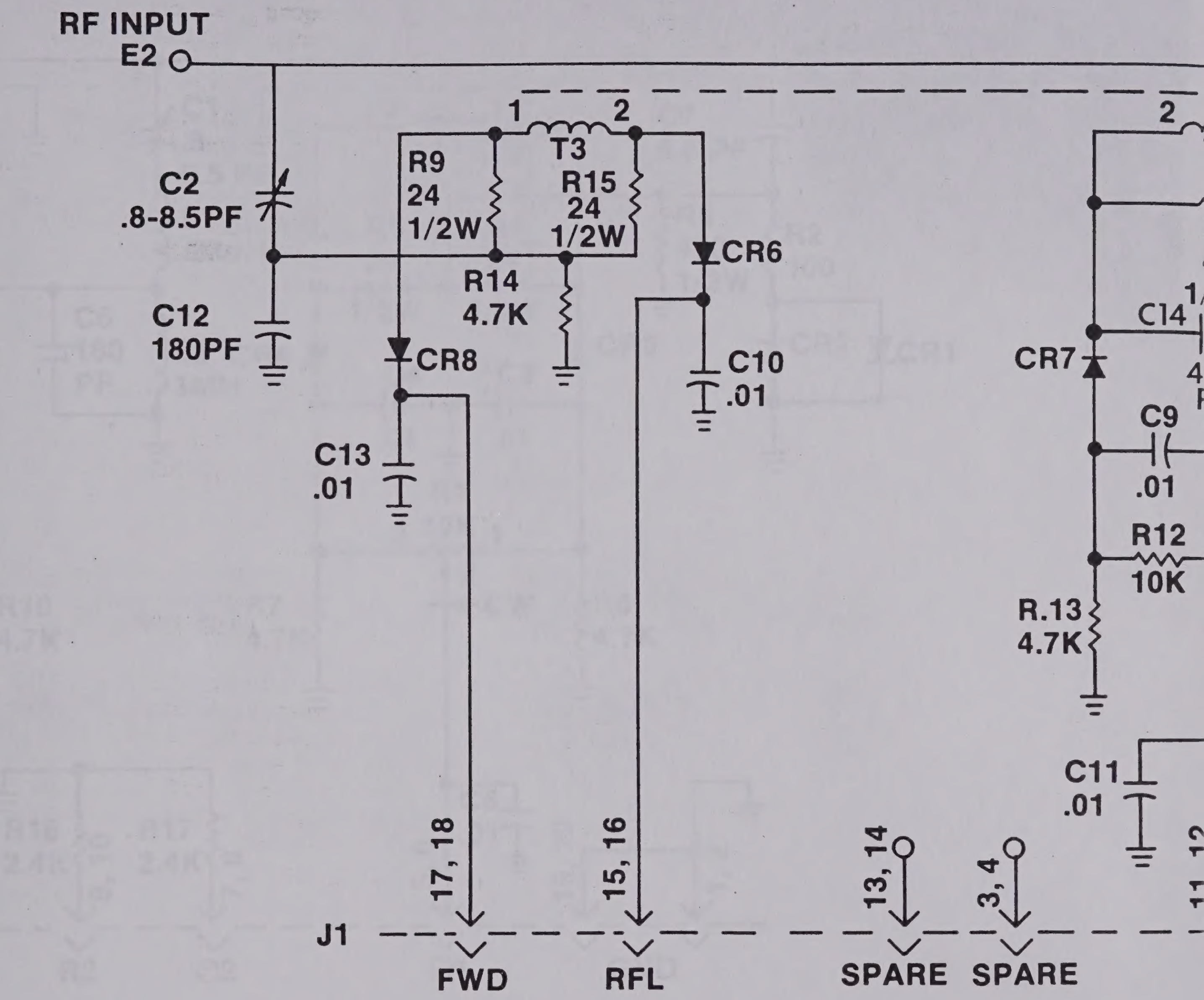


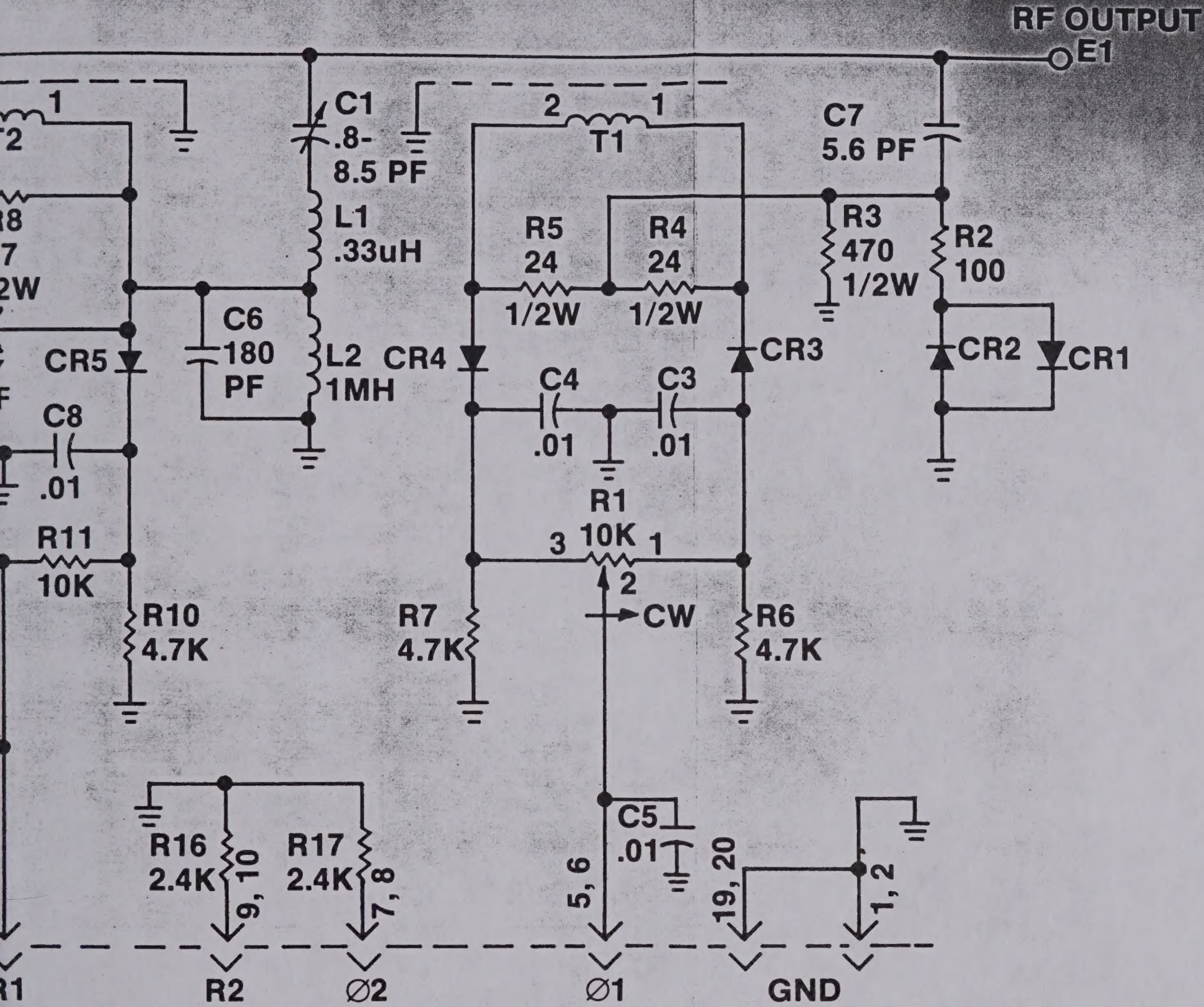
Figure 4.3 Detector Board Component Location

Detector Board

SYMBOL	DESCRIPTION	PART NUMBER
C1, C2	Capacitor, variable, .8 - 8.5 pf	600058-217-001
C7	Capacitor, 5.6 pf	600269-314-006
C3 thru C5 C8-C11, C13	Capacitor, .01 uf, 50V	600272-314-002
C6, C12	Capacitor, 180 pf	618003-306-501
CR1-CR8	Diode, HP 2800	600118-410-001
L1	Coil, .33 uH	600125-376-001
L2	Coil, 1000 uH	600034-376-001
R1	Resistor, variable, 10K	600063-360-010
R2	Resistor, 100, 1/4W, 5%	610004-341-075
R3	Resistor, 470, 1/2W, 5%	647004-341-205
R4, R5, R9, R15	Resistor, 24, 1/2W, 5%	624094-341-205
R6, R7, R10, R13, R14	Resistor, 4.7K, 1/4W, 5%	647014-341-075
R8	Resistor, 47, 1/2W, 5%	647094-341-205
R16, R17	Resistor, 2.4K, 1/4W, 5%	624014-341-075
R11, R12	Resistor, 10K, 1/4W, 5%	610024-341-001
T1, T2, T3	Detector, toroid	600138-512-001



NOTES:
1. UNLESS OTHERWISE NOTED, ALL RESISTOR
5%. CAPACITORS ARE IN MICROFARADS. AL
2. ALL REF. DESIGNATIONS ARE PRECEDED B



ARE IN OHMS AND ARE ¼ W±
DIODES ARE HP-2800.
1A2A2.

Figure 4.4 Detector Board Schematic